Water Plant Optimization Study

TILBURY WATER TREATMENT PLANT

June 1991

Ontario Environment Environnement

ISBN 0-7729-3316-2

WATER PLANT OPTIMIZATION STUDY

Tilbury
Water Treatment Plant

Project No. 7-2032

June 1991

RECYCLABLE

Cette publication technique
n'est disponible qu'en anglais.

PIBS 1561
log 89-2302-157

Study conducted by:

D. S. Madill
of
LA FONTAINE, COWIE, BURATTO & ASSOCIATES LIMITED

Under the direction of the
Tilbury Project Committee:

Gary Martin - MOE Water Resources Branch
Hector Donais - Tilbury Public Utilities Commission
Gaston Bouillon - MOE Tilbury Water Treatment Plant
Mike Auger - MOE Southwest Region
Bill Gregson - MOE Project Engineering Branch
Janusz Budziakowski - MOE Environmental Approvals Branch
Gerry Sigal - R. V. Anderson Associates Limited

Address all correspondence to:

Ministry of the Environment
Water Resources Branch
1 St. Clair Ave. W., 4th Floor
Toronto, Ontario
M4V 1K6

Please note that some of the recommendations contained in this report may have already been completed at time of publication. For more information, please contact the local municipality, or the Water Resources Branch of the Ministry of the Environment.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

The purpose of the Water Plant Optimization Study is to produce a document that describes the present condition of a water plant with respect to equipment and operation as well as information regarding the quantity and quality of raw and finished water. The report attempts to make recommendations that will allow the plant to operate in an optimum condition so that the best possible finished water quality is achieved with emphasis on particulate removal and disinfection. The approach is to optimize the existing facilities and make recommendations for short term and long term improvements. It is anticipated that the optimization study documents will be updated annually.

The Tilbury Water Treatment Plant had its beginnings in the 1930's and has undergone expansions and modifications over the years. Until March 1987 the plant was operated by the Tilbury Public Utilities Commission. Since then, the Ministry of the Environment has operated the plant under an agreement with the P.U.C.

The absence of reliable data for 1985 and 1986 makes it difficult to assess the plant operation. Recently acquired turbidity measuring instruments are providing more accurate records of raw and finished water turbidity. Clarifier effluent turbidity is not measured which precludes evaluating the effectiveness of the clarifier.

To allow an assessment of plant operation and to optimize particulate removal and disinfection at the Tilbury Water Treatment Plant, the following are suggested:

PHYSICAL IMPROVEMENTS

- Install level sensing instrumentation and alarm in raw water well.
- Install continuous turbidity recording instrumentation with alarms for raw water.
- Install continuous turbidity monitoring instrumentation on the effluent of each filter and the clarifier.
- Cover the clarifier.
- Modify plant effluent sampling system to achieve a higher velocity in the sample line.
- Provide chlorine cylinder scales.

- Install chlorine residual analyser/ recorder with alarm to monitor plant effluent.
- Consider flow pacing of treatment chemicals to complement the proposed raw water flow measurement system.

STUDIES

- Testing should be done to determine if filter-to-waste operation would be beneficial.
- A streaming current monitor should be obtained for a trial period to determine if it would be beneficial.
- The need for taste and odour control should be re-evaluated and if found to be necessary, powdered activated carbon should be evaluated.

OTHER RECOMMENDATIONS

- Operators should receive training in the correct operation of ClO_2 systems.
- Acid should be used to adjust pH in the ClO_2 system instead of excess Cl_2.
- Production of an operating manual for the plant.
- The plant should be included in the MOE Drinking Water Surveillance Program.
- Improve plant security by providing intrusion alarms or through other means.
- Consider installing a system to give a remote alarm if the lone operator needs assistance.
- Piping should be colour-coded.
- Total chlorine residual should be recorded in the daily log.

WATER PLANT OPTIMIZATION STUDY

TILBURY WATER TREATMENT PLANT

ONTARIO MINISTRY OF THE ENVIRONMENT

PROJECT NO. 7-2032

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION AND TERMS OF REFERENCE

The purpose of the Water Plant Optimization Study (WPOS) is to document and review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on the removal of particulate materials and the disinfection processes.

In striving for excellence in water treatment, it is important to examine all possible approaches, but first, optimum use should be made of the processes already in place.

This optimization study is a beginning and not an end to itself; it is the start of an ongoing documentation of the operation of the plant. It is recommended that this document be updated on an annual basis.

The Ontario Ministry of the Environment has instituted a Drinking Water Surveillance Program (D.W.S.P.) consisting of a continuously updated base of information on Ontario water treatment plants and water quality. In connection with the D.W.S.P., a specific plant investigation and process evaluation study is required for each plant entering the program. The study has been prepared in accordance with a detailed protocol prepared by the Ministry of the Environment.

The Tilbury Water Treatment Plant provides the water supply for approximately 2,280 customers in the Town of Tilbury and parts of the Townships of Tilbury East and Tilbury North.

The Optimization Study is based on plant operating data for the years 1986 and 1987.

Until March 1987 the plant was operated by Tilbury Public Utilities Commission. Subsequently, the plant has been operated by the Ontario Ministry of the Environment.

SECTION A
RAW WATER

A.1 Source

The source of raw water for the Tilbury Water Treatment Plant is Lake St. Clair. The plant is located in the Township of Dover on the south shore of Lake St. Clair approximately 1.5 km (1 mile) east of where the Thames River discharges to the Lake (Figure 1). Agricultural, commercial and industrial developments upstream on both the Thames and the St. Clair Rivers may impact on the raw water quality. The intake structure is approximately 1,012 metres (3,300 ft) offshore, and water is drawn from a depth of approximately 2.0 metres (6.6 ft) below mean lake level and discharges through a 460 mm (18 in) diameter intake pipe to the shoreline and approximately 70 m (230 ft) to the plant.

A.2 Quality

Raw water quality is affected by silt-laden runoff discharged to the lake by the Thames River. Lake St. Clair is very shallow and wave action disturbs bottom sediments and increases turbidity dramatically.

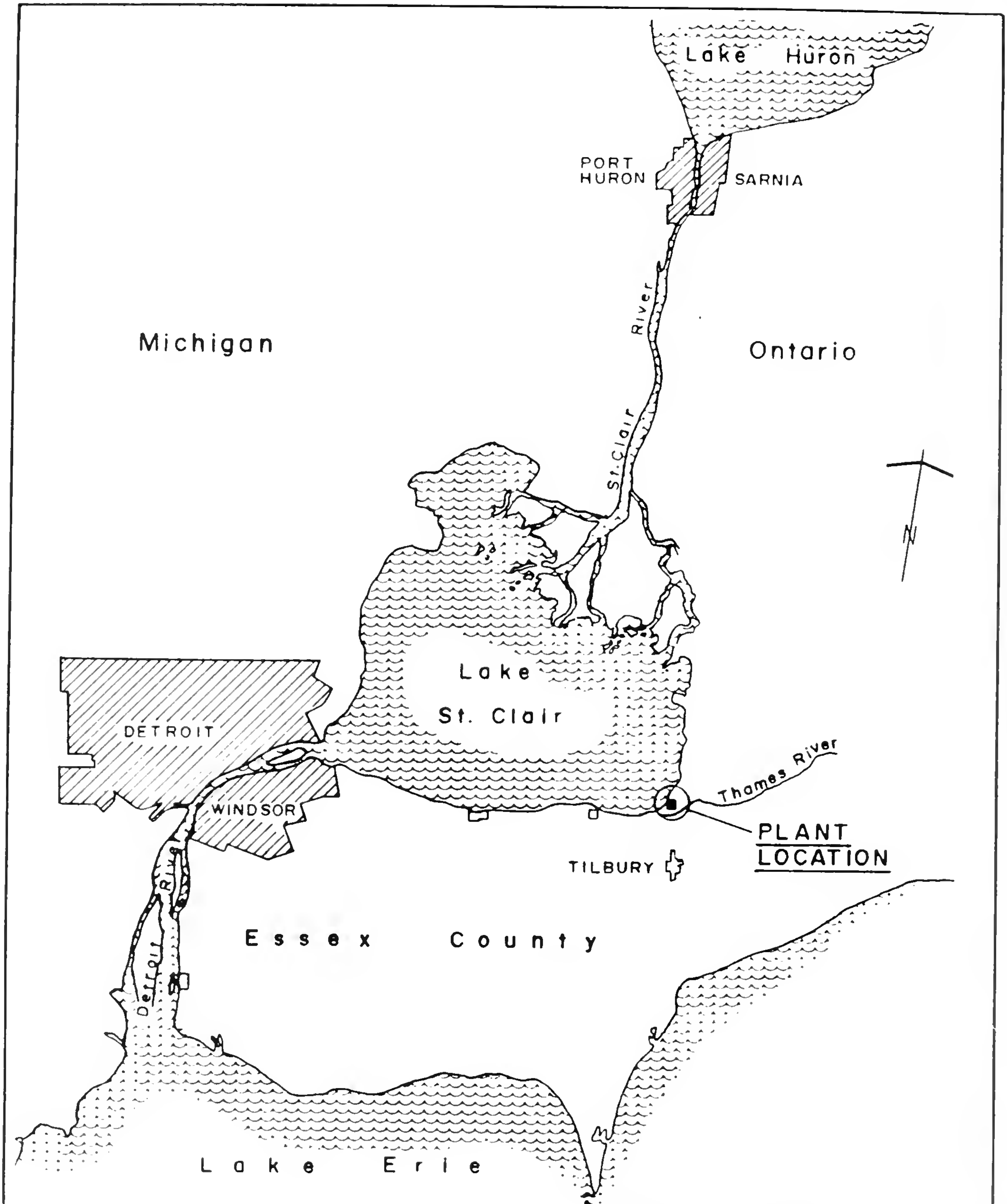
For 1987 raw water turbidity varied as follows:

Parameter	Min.	Max.*	Avg.**
Turbidity (FTU)	3	505	40

* turbidity fluctuates rapidly and widely - hourly maximums may reach 3,000 FTU.

** turbidity is <20 FTU fifty percent of the time.

Test results of other raw water chemical and physical parameters were not available.



WATER PLANT OPTIMIZATION STUDY
OME Project N° 7-2032

TILBURY
WATER TREATMENT PLANT

LOCATION MAP

0 10 20
SCALE - KILOMETRES

Date	88 03 03
File N°	WR 158 T

Figure N° 1

Bacteriological tests on the raw water for the last nine months of 1987 yielded:

Parameter	% of Samples
Total Coliforms	
0-100/100 mL	76
101-5000/100 mL	24
> 5000/100 mL	0
Fecal Coliforms	
0-10/100 mL	76
11-500/100 mL	24
> 500/100 mL	0
Fecal Streptococcus	
0-1/100 mL	68
2-50/100 mL	23
> 50/100 mL	9

Bacteriological tests for the previous part of the study period were not available.

SECTION B
FLOW MEASUREMENT

B.1 Raw Water Flow

Raw water flow is not measured.

B.2 Treated Water Flow

Treated water flow is measured by a 300 mm (12 in) diameter Venturi. The Venturi is installed in the plant discharge main and is buried. The Venturi pressure taps are piped to two differential pressure cells. One of the D/P cells is connected to a flow indicator and the other is connected to a circular chart recorder. The flow measuring system is not calibrated on a regular basis.

B.3 Backwash Water Flow

Backwash water flow is not measured.

B.4 Filter Flow

The flow through each filter is not measured. The total filter flow can be obtained from the plant effluent flow meter in B.2 above.

SECTION C
PROCESS COMPONENTS

C.1 General

The plant components include an intake, raw water screens, low lift pumps, solids contact upflow clarifier, high lift pumps and pressure filters (Figure 2). The plant has chemical facilities for coagulation, disinfection, fluoridation and taste and odour control. Refer to Figure No. 3 and Figure No. 4 - Block Schematic in Appendix A for details of plant components. Section C.8 contains photographs of the plant and plant components.

C.2 Design Data

a) Plant Capacity

The nominal hydraulic capacity of the plant is approximately 6.8 ML/d (1.5 mgd) and is based on a filtration capacity at a filtration rate of 4.9 m/hr (1.67 gpm/sq ft). The clarifier has an hydraulic capacity of 13.6 ML/d (3.0 mgd).

C.3 Process Component Inventory

a) Intake

The original plant intake installed in the 1930's was a 400 mm (16 in) diameter pipe extending approximately 1,012 m (3,320 ft) from shore terminating at an intake structure. In the late 1960's the intake became plugged and a temporary inlet was made to the intake pipe near the shoreline. Subsequently, the lake portion of the intake pipe was replaced with 460 mm (18 in) diameter corrugated steel pipe. The intake pipe from the shoreline for the plant is the original 400 mm (16 in) diameter pipe. Details of the inlet structure at the end of the intake are not available.

b) Screening

Raw water is screened at the low lift pump well (as described in Figure 3) inlet by two 1.2 metre (4 ft) wide by 1.2 metre (4 ft) high galvanized wire

TILBURY WATER TREATMENT PLANT

BLOCK DIAGRAM

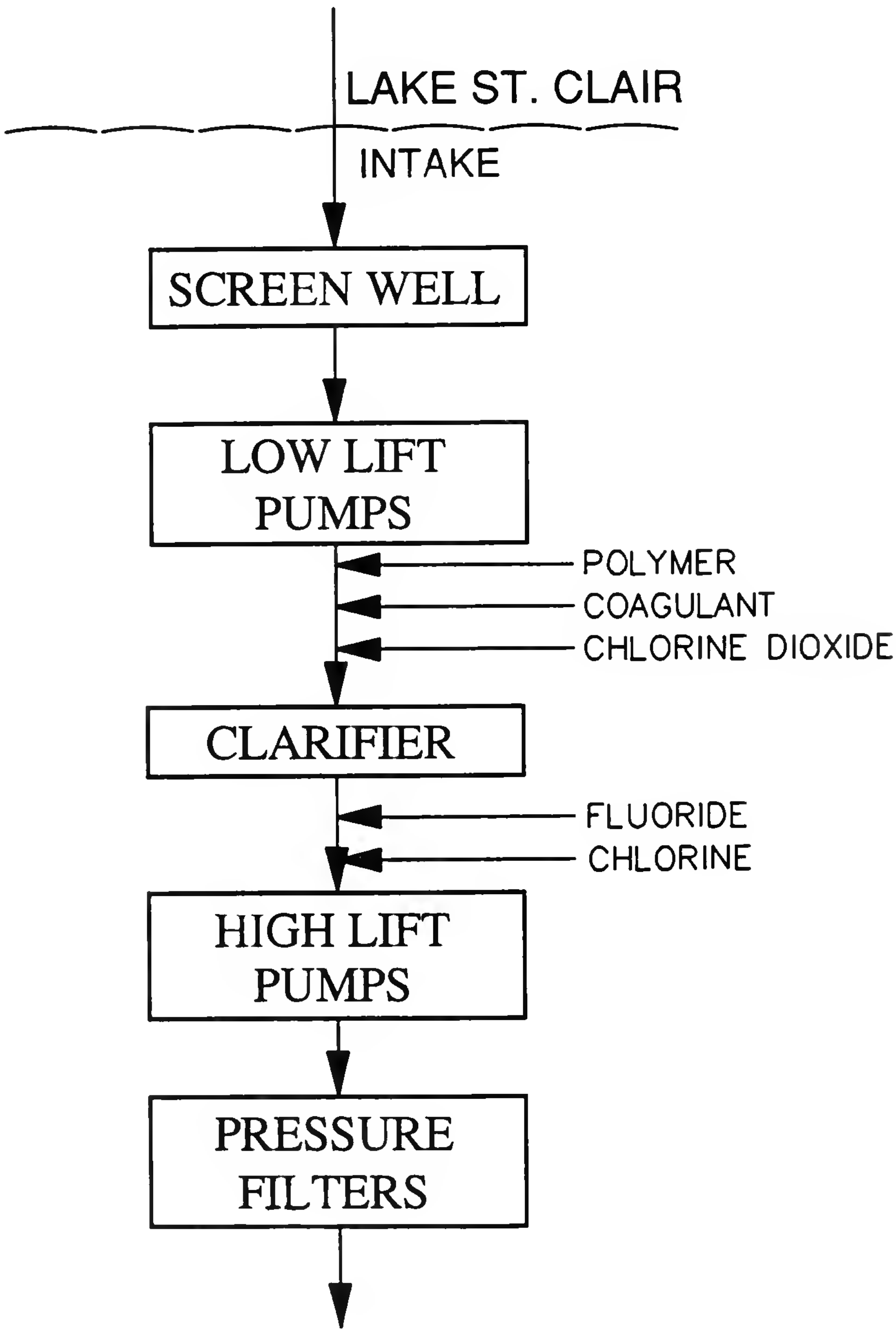


Figure 2.

mesh screens with 13 mm (½ in) openings. The screens are removed manually for cleaning.

c) Low Lift Pumping

The low lift pumping system is comprised of three Allis Chalmers horizontal centrifugal pumps driven by electric motors and having the following performance characteristics:

LL-1:	5.24 ML/d (1.15 mgd) at 8.2 m (27 ft) TDH with 7.46 kW (10 HP) motor
LL-2:	7.85 ML/d (1.73 mgd) at 11.58 m (38 ft) TDH with 14.9 kW (20 HP) motor
LL-3:	5.24 ML/d (1.15 mgd) at 8.2 m (27 ft) TDH with 11.2 kW (15 HP) motor

Low lift pump LL-1 is in need of an overhaul and is not used. The firm capacity (ie. capacity with the largest pump out of service) is 5.24 ML/d (1.15 mgd). The pumps discharge to a common header and raw water flows through approximately 30 m (100 ft) of 400 mm (16 in) diameter pipe to the clarifier. Under power failure, emergency power is supplied to the low lift pumps from the standby diesel engine generator.

d) e) f) Clarification

Flash mixing, flocculation and settling occur in an outdoor reinforced concrete tank 18.3 metres (60 ft) diameter by 4.27 metres (14 ft) side water depth with Eimco solids contact upflow clarifier internals (as shown in Figure 5 of Appendix A). Clarified water is removed through orifices in submerged radial collection tubes to allow for winter operation. The plant staff has installed radial floating wooden baffles to diminish the effects of wind on clarifier operation. Scrapers move settled sludge to the central hopper from which it is discharged to the sludge settling pond.

The clarifier has a rating of 13.64 ML/d (3.0 mgd) and has an overflow rate of 2.16 m/h (0.74 gpm/sq ft) based on the total tank area and 2.66 m/h (0.91 gpm/sq ft) based on the area of the settling zone. The total volume of the clarifier is 1,312 m^3 (290,000 gal) which gives a retention time of 139 minutes @ 13.64 ML/d (3.0 mgd). At the nominal plant design capacity of 6.8 ML/d (1.5 mgd) the overflow rate is 1.08 m/h (0.34 gpm/sq ft) and detention time is 279 minutes.

g) High Lift Pumping

The plant has no treated water storage. Settled water is pumped by the high lift pumps through the pressure filters directly to the plant discharge main. The high lift pumping system consists of three horizontal centrifugal pumps as follows:

HL-1:	Worthington	- 7.5 ML/d (1.66 mgd)
		- 111 kW (150 HP) electric motor
HL-2:	Worthington	- 7.5 ML/d (1.66 mgd)
		- 111 kW (150 HP) electric motor/diesel engine drive
HL-3:	DeLaval	- 3.27 ML/d (0.72 mgd)
		- 74.6 kW (100 HP) electric motor

High lift pump HL-3 is in need of an overhaul and is not operable. The firm capacity (ie. capacity with the largest pump out of service) is 7.5 ML/d (1.66 mgd).

Pump suction piping is connected directly to the 400 mm (16 in) dia. clarifier effluent pipe.

Control of the high lift pumps is limited to stop/ start manual operation. Manual closing of the pump discharge control valve is required prior to stopping the high lift pump in order to reduce water hammer.

h) **Filters**

The plant has six horizontal cylindrical pressure filters, two of which are installed outdoors and are utilized only during the summer months.

Filter Nos. 1 , 2 and 3

Capacity: 1.4 ML/d (0.3 mgd) each @ 4.9 m/h (1.67 gpm/sq ft) filtering rate

Size: 2.4 m (8 ft) dia. x 4.9 m (16 ft) long

Underdrains: Miller Block

Media: Estimated at 1,190 mm (46 in) depth of graded anthracite Effective sizes (E.S.) and uniformity coefficients (U.C.) were not available.

Filter No. 4

Capacity: 2.63 ML/d (0.58 mgd) @ 4.9 m/h (1.67 gpm/sq ft) filtering rate

Size: 3 m (10 ft) dia. x 7.3 m (24 ft) long

Underdrains: Pipe laterals

Graded Gravel*: 400 mm total depth
100 mm - 25 mm x 19 mm
75 mm - 19 mm x 12.5 mm
75 mm - 12.5 mm x 6 mm
75 mm - 6 mm x 3 mm
75 mm - 3 mm x 1 mm

Anthracite: Estimated at 760 mm depth
E.S. and U.C. were not available.

* As indicated on historical drawings.

Filter Nos. 5 and 6 (outdoor)

Capacity:	1.4 ML/d (0.30 mgd) @ at 4.9 m/h (1.67 gpm/sq ft) filtering rate
Size:	2.4 m (8 ft) dia. x 4.9 m (16 ft) long
Underdrains:	Miller Block
Media:	Anthracite E.S. and U.C. were not available.

The filters installed outdoors are in need of being overhauled and are not in operable condition.

Normally, all the filters installed in the building (Filter Nos. 1 to 4) are in operation and because the flow through each filter is not measured, it is not possible to calculate volumes of water filtered per cycle. In addition, there are no provisions for measuring loss of head through the filters.

Filter backwash water is stored in a 68 m^3 (15,000 gal) elevated tank. This storage volume would allow washing Filter No. 4 for approximately 4 minutes at a rate of 45 m/h (15 gpm/sq ft) and Filter Nos. 1, 2 and 3 for approximately 8 minutes.

Filter backwash wastewater discharges to a settling pond.

The filter piping arrangement allows for filtering-to-waste but is not used.

(i) Backwash Treatment and Sludge Disposal

The plant has two settling ponds, one for clarifier sludge blow down and the other for filter backwash wastewater. Supernatant from the ponds is pumped to the lake and when required, settled sludge is dredged from the ponds and spread on the land around the periphery of the ponds to dry.

C.4 Chemical Systems

a) Taste and Odour Control and Disinfection

(i) Taste and Odour Control (Chlorine Dioxide)

The plant has facilities for producing chlorine dioxide for taste and odour control and primary disinfection. It is fed to the raw water in the low lift pump discharge piping.

Sodium chlorite powder (80% sodium chlorite) is stored in 77 kg (170 lb) drums. It is batch mixed with water in a tank in the ratio of 3.64 kg (8 lb) of sodium chlorite to 118 litres (26 gal) of water forming a 2.5% solution. The sodium chlorite solution is pumped into a chlorine solution stream by a Wallace & Tiernan Model A-747 diaphragm metering pump. The chlorine solution stream is produced by a system incorporating liquid chlorine stored in 68 kg (150 lb) cylinders, two Advance Model 201 4.5 kg/day (10 lb/day) gas chlorinators and an injector. The combined chlorine/sodium chlorite solutions are passed through a chlorine dioxide generator and discharged to the low lift pump discharge header.

(ii) Disinfection (Post-Chlorination)

Chlorine is added to the clarifier effluent to maintain a 1.5 mg/L free chlorine residual in the plant effluent. The post-chlorinator is a Wallace & Tiernan Model A-747 gas chlorinator with a 0-23 kg/day (0-50 lb/day) rotameter.

b) Coagulant

Prior to February 1986 liquid alum was used as a primary coagulant. Subsequent to that time, the primary coagulant has been polyaluminum chloride. The coagulant storage and feed system is comprised of the following:

- 1 - 23 m^3 (5,000 gal) insulated and heat traced outdoor fibreglass storage tank
- 1 - Wallace and Tiernan Model A-747 single head diaphragm metering pump, max. capacity 1.32 L/min (14.5 gal/hr). The pump suction has a calibration chamber for verifying pump delivery. The pump is calibrated at least once per day.

The maximum dosage rate of polyaluminum chloride is 111 mg/L at a plant flowrate of 6.82 ML/d (1.50 mgd)

c) Coagulant Aid

The plant has a 0.57 m^3 (125 gal) polyethylene tank and a Wallace and Tiernan Model A747 diaphragm metering pump that was previously used for mixing and feeding a liquid polymer coagulant aid. At the present time, coagulant aid is not being used.

d) Fluoride

Fluoride is added to the clarifier effluent to maintain a residual of 1.2 mg/L in the plant effluent. Fluoridation is accomplished using granular sodium fluoride (97% NaF) which is received and stored in 45.5 kg (100 lb) cardboard containers.

Sodium fluoride solution is prepared in a 0.114 m^3 (30 gal) polyethylene saturator tank which contains a granular support layer on top of which sodium fluoride is added. The tank is filled with softened water (controlled by a level switch) and the saturated sodium fluoride solution is withdrawn from a manifold at the bottom of the tank under the granular support layer. The sodium fluoride solution is pumped to the clarifier effluent by a Wallace and Tiernan Model 44-747 diaphragm metering pump to maintain the fluoride ion concentration of 1.2 mg/L in the plant effluent. The feed pump has a maximum capacity of 1.32 L/min (14.5 gal/hr) and is capable of fluoridating up to 24.4 ML/d (5.4 mgd) of water.

C.5 Sampling and Testing

a) Turbidity

Turbidity of a continuous flow of **raw water** is measured and indicated by a Hach Surface Scatter 5 Turbidimeter (Model No. 15625) located in the laboratory. The sample is taken from the low lift discharge header and travels through approximately 11 m (36 ft) of 12.7 mm (½ in) diameter pipe to the turbidimeter. Sample flow rate is approximately 3.6 L/min (0.66 gpm) which yields a velocity of 0.38 m/sec (1.25 ft/sec) and a travel time of 29 sec. The raw water turbidity indication is observed 2 to 4 times daily and the average value is recorded on the daily log sheet.

Turbidity of a continuous flow of **finished water** is measured and indicated by a Hach Model 1720B Turbidimeter located in the laboratory. During periods when the turbidity is not stable, it is recorded on a strip chart recorder. The sample is taken from the plant effluent piping and travels through approximately 30 m (100 ft) of 19 mm ($^3/_4$ in) diameter copper tube to the turbidimeter. The sample flow rate is approximately 500 mL/min (5.5 gal/hr) which yields a line velocity of 0.03 m/sec (0.10 ft/sec) and a travel time of approximately 20 minutes. Plant effluent turbidity is recorded once per day.

b) Chlorine Residual

Chlorine residuals are measured by a Hach Colorimeter.

Clarifier effluent is tested for free chlorine residual every 4 hours and the result of each test is recorded on the daily log sheet. Clarifier effluent samples are obtained from a continuously running stream just inside the north wall of the plant opposite the clarifier. The sample is taken from the same elevation as the clarifier collection tubes and travels through approximately 20 m (65 ft) of 19 mm ($^3/_4$ in) diameter pipe to the sample collection location. Sample flow rate is approximately 6.8 L/min (1.25 gpm) yielding

a velocity of 0.8 m/sec (2.62 ft/sec) and a travel time of approximately 55 sec.

Samples of **plant effluent** are tested for chlorine residual every 4 hours and all test results are recorded. Plant effluent samples are obtained from the turbidimeter discharge.

c) **pH**

Samples of **raw water** and **treated water** are tested for pH once per day and the results are recorded in the daily log.

d) **Fluoride**

Samples of plant effluent are tested for fluoride ion concentration twice per day using the Hach Colorimeter and Spadins reagent and the results are recorded in the daily log.

C.6 Process Automation

The only automatic operation in the plant is clarifier sludge blow down.

C.7 Standby

The plant has a Kohler 50 kW diesel engine generator which is capable of supplying power to one low lift pump and all other plant facilities except the high lift pumps. Upon power failure, the generator automatically starts operation and powers the lighting system. All other plant functions must be started manually. Standby high lift pumping is provided by a pump which is driven by a Cummins 111 kW diesel engine.

C.8 Photographs

Following are photographs illustrating the plant and its components.

North elevation of plant. Filter backwash wastewater settling pond in left foreground.

View of plant looking south. Clarifier sludge settling pond in right centre.

South elevation of plant.

Outdoor filters and south elevation at residence.

Clarifier

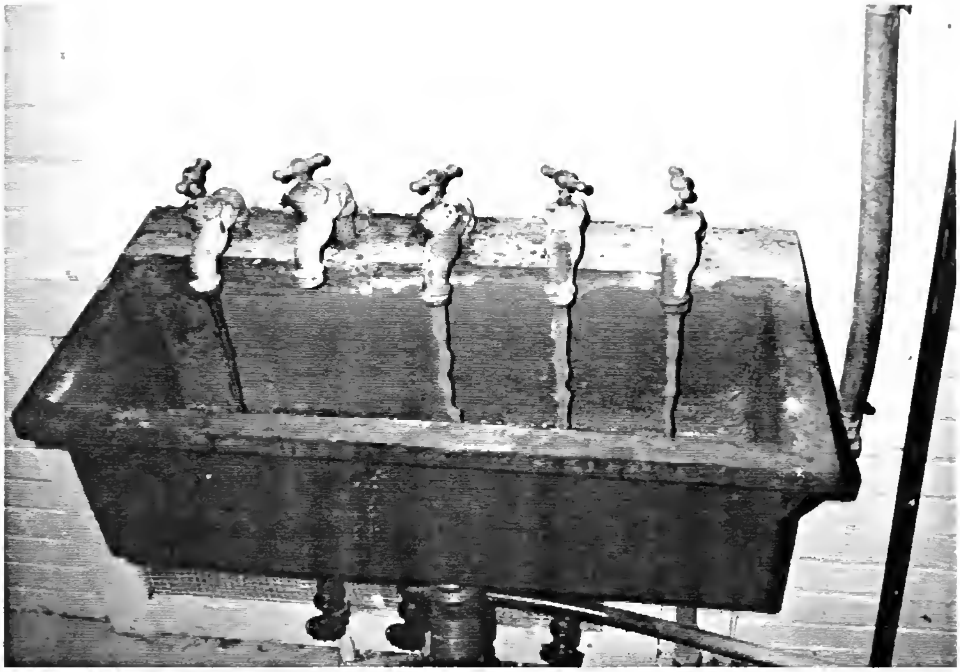
View looking northerly showing coagulant tank and settling ponds. Lake St. Clair in background.

Clarifier

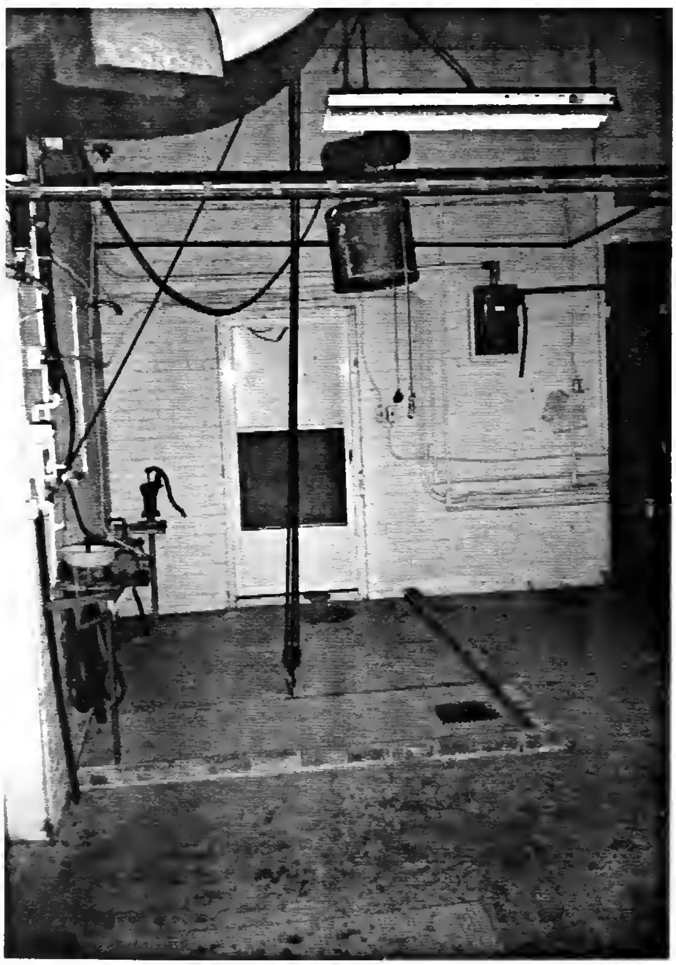
Clarifier sludge blowdown building at upper right.

Clarifier sludge building. Compressed air system for sludge blowdown valve operator.

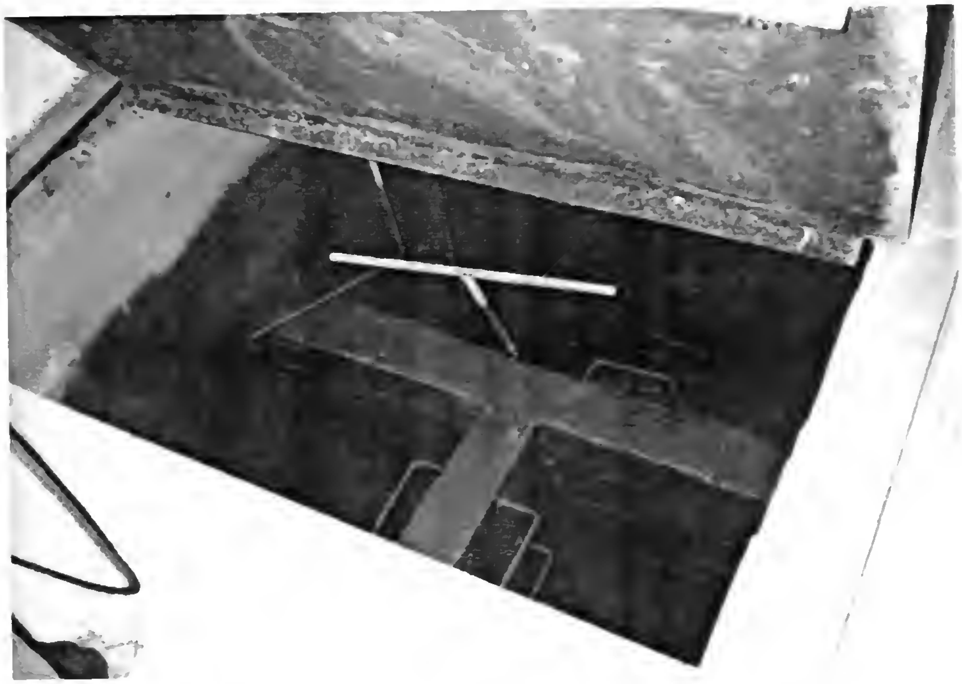
Clarifier sludge building. Sludge blowdown piping and valves.



Clarifier sample station in main plant building.



Low lift pumpwell inlet access hatches.



Low lift pumpwell inlet.

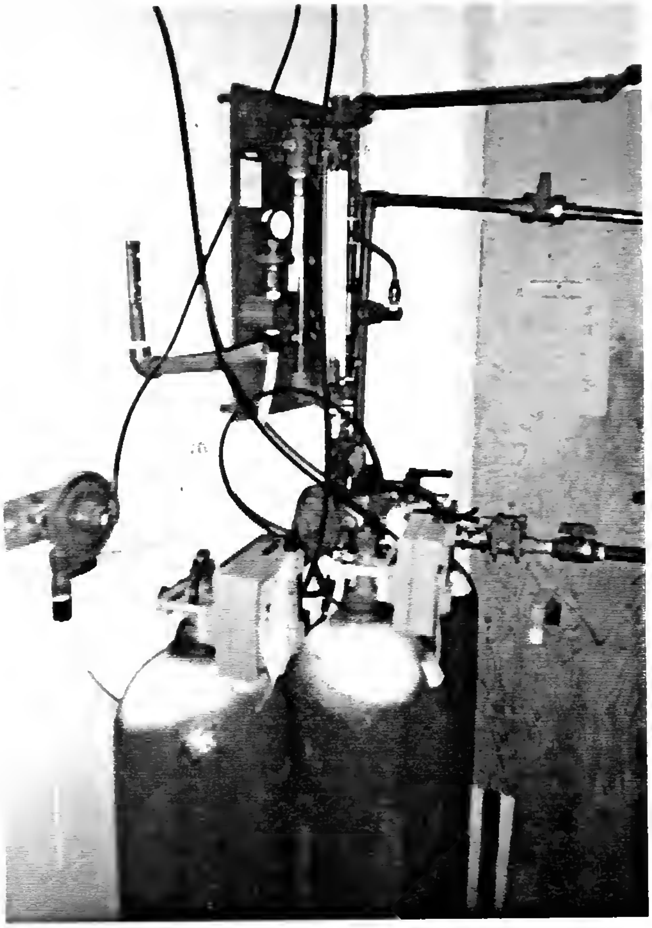
Low lift pumps.

Coagulant feed pump - left centre. Drums of trial coagulant.

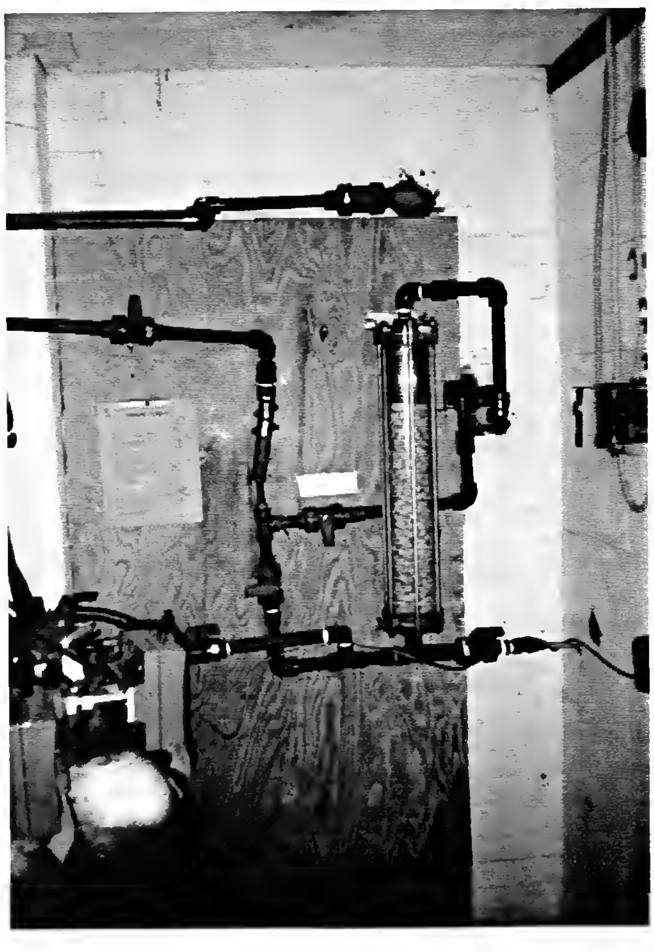
Fluoridation system.


Sodium chlorite system.


Chlorine cylinders and chlorinators.



Chlorine cylinders and chlorinators.

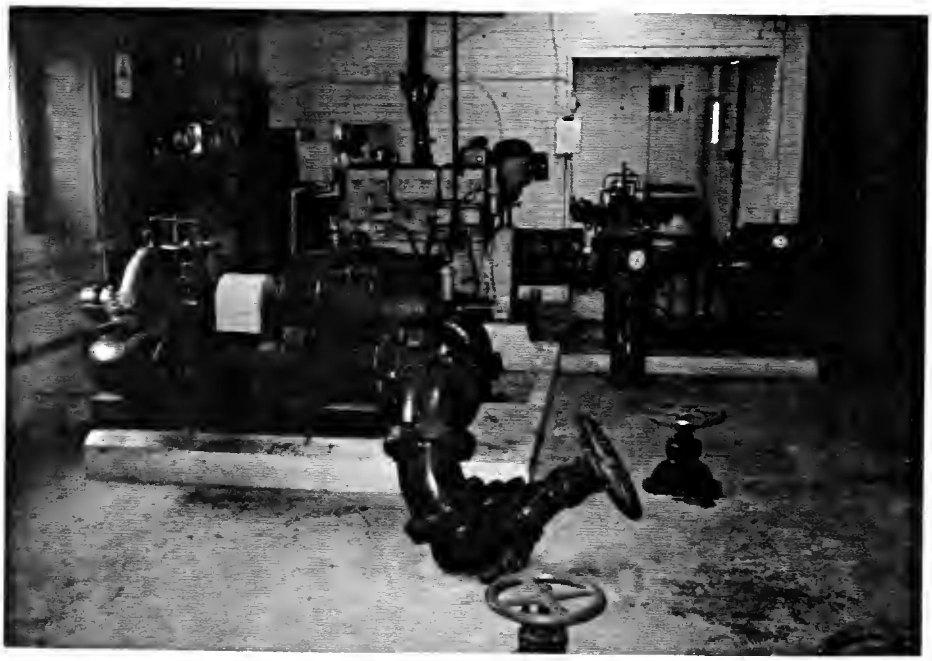


Chlorine solution, piping and chlorine dioxide generator.

Chlorine cylinder storage in chlorine room.

Outside chlorine cylinder storage.

Coagulant aid mix and storage tank. Sodium fluoride storage.



High lift pumps.

Electric motor/diesel engine driven High Lift Pump HL-2, High Lift Pump HL-1 in left background.

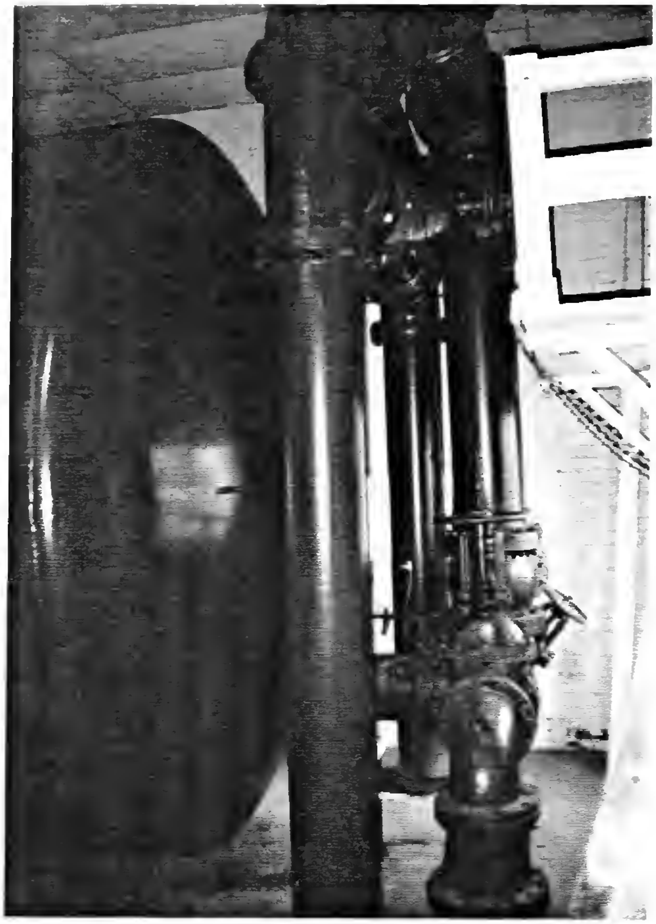
High Lift Pump HL-3.

Filters 1, 2 and 3 and filter piping.

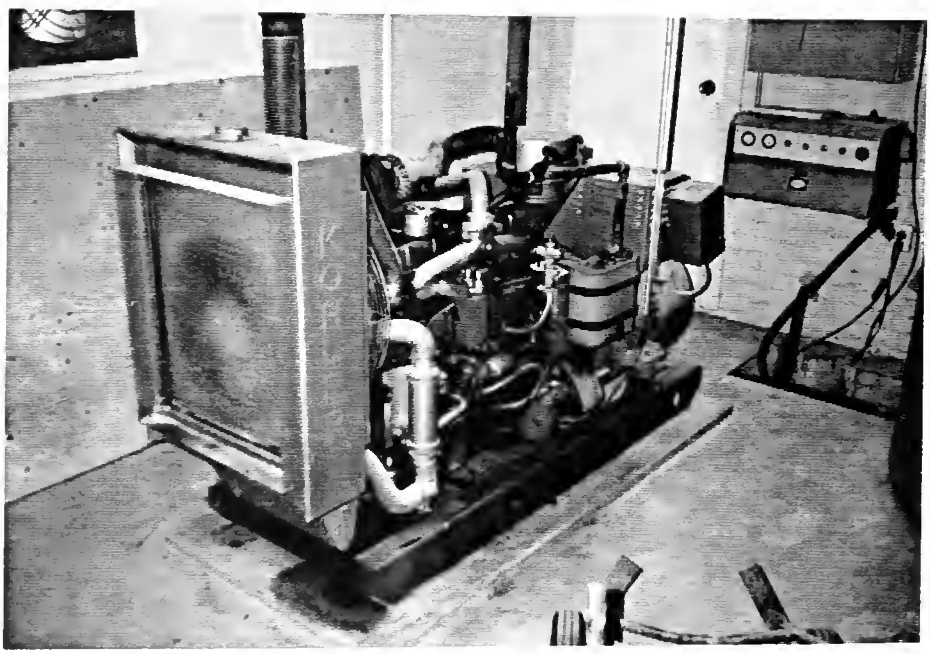
Close up of Filter No. 1 piping.

Filter No. 1 inlet piping.

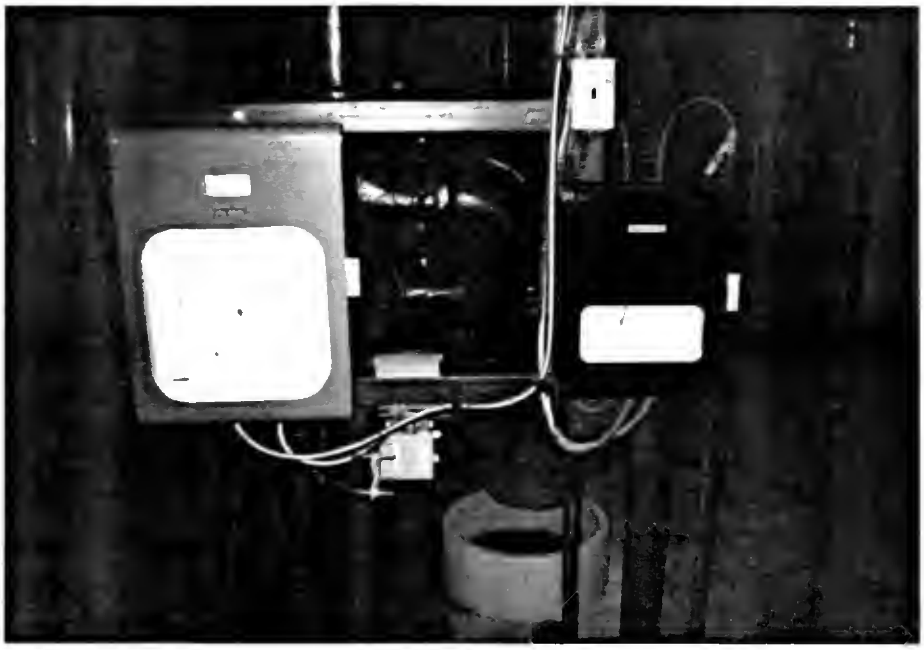
Filter No. 4.



Filter No. 4 piping.



Diesel engine generator.



Plant effluent flow indicator and recorder.

Laboratory

Plant effluent turbidimeter.

Raw water turbidimeter.

SECTION D
PLANT OPERATION

D.1 General Description

Although the Tilbury Water Treatment Plant is approximately 7.5 km (4.6 mi), from the major water demand centre, the Town of Tilbury, the driving distance is approximately 31 km (20 mi). Four and one half kilometers (2.8 mi) of the distance is on an unimproved road through private property that can be impassable after snow storms and during spring thaw. Because of the uncertain access, living quarters were constructed at the plant site.

The plant staff consists of a chief operator, one full time operator and one part-time operator. From May to October the plant operates on a continuous basis and each operator is on duty for 24 hours every third day. From November to April, the water demand is such that the plant is not required to operate every day. During this period the part-time operator is laid off and the two operators each work 24 hour shifts every third day.

Living quarters are attached to the plant and as well as operating the plant during normal working hours, the operator on duty checks the operation of plant equipment every 2 hours from 4:00 p.m. to 8:00 a.m. On days when the plant is shut down, only the clarifier rake and turbine operate. During these periods, there is no staff at the plant.

Plant security is limited to locked perimeter fencing topped with razor wire.

Control of flow through the plant is very basic. Normally, low lift pump LL-1 and high lift pump HL-2 are in operation and a gate valve on the low lift pump discharge is manually adjusted to maintain a proper operating level in the clarifier. Clarifier level is indicated in the plant in a sight glass which is monitored by the operator. Generally, the low lift discharge valve does not require adjustment more frequently than at 4 hour intervals.

Plant effluent flows 6.5 km (4 mi) to an underground storage and repumping facility located north of the Town of Tilbury. Water level in the reservoir is transmitted to and recorded at the water treatment plant and an alarm sounds on high level. When this

occurs, the water plant operator will manually shut down the plant. When the reservoir level falls to a preset value, the operator will manually start up the water treatment plant process. (See Plant Start-up and Shut-down procedures in Appendix A.)

D.2 Disinfection Practices

Disinfection is accomplished by the use of chlorine and chlorine dioxide. Chlorine is stored in 68.2 kg (150 lb) cylinders and is put into solution with water through the use of gas chlorinators. The plant has three chlorinators. One of the chlorinators is for post-chlorination, one is for producing a chlorine solution for chlorine dioxide generation and the third is a standby for the chlorine dioxide generation system. Duty is rotated on all three chlorinators.

The chlorine dioxide system is primarily for taste and odour control, but as well, serves as a pre-disinfectant. This system uses excess chlorine and is operated to maintain a free chlorine residual of 1.0 mg/L in the clarifier effluent. Use of chlorine dioxide as an oxidant in raw water would tend to discourage the formation of trihalomethanes provided excessive amounts of chlorine are not used. It would appear that since the chlorine feed rate is adjusted to maintain a 1.0 mg/L free chlorine residual in the clarifier effluent that the potential exists for formation of trihalomethanes. Trihalomethanes test results were available for the raw water and the plant effluent but not for the intermediate process streams.

	Total Trihalomethanes (ug/L)	
Date	**Raw Water**	**Plant Effluent**
87/05/10	n.d.	115
87/06/03	n.d.	77
87/08/05	n.d.	160
87/09/16	n.d.	304
87/10/07	n.d.	116

n.d. = not detected

The test results confirm the formation of trihalomethanes in concentration at times approaching the Provincial Drinking Water Objective of 350 ug/L.

Post-chlorination chlorine solution is added to the clarifier effluent (ie. high lift pump suction) in quantities to maintain a 1.5 mg/L free chlorine residual in the plant effluent.

Chlorine feed rates are set manually and are adjusted when required to correct for deviations from the residual objective.

The plant does not have chlorine scales and it is therefore not possible to verify chlorine dosages by weight on a daily basis. Clarifier effluent chlorine dosages recorded on the Utility Monitoring Sheets are calculated by multiplying the chlorinator rotameter readings by the hours of operation to obtain the daily amount of chlorine used. This figure is divided by the volume of water treated to arrive at the average daily chlorine dosage.

D.3 Operation of Specific Components

.1 Intake

Frazil ice has occurred about four times each winter season which completely stopped flow through the intake. The ice was successfully flushed from the intake by pumping water into a standpipe on the intake (at the shore) with a gasoline engine pump.

.2 Screening

The low lift pump well inlet has two 1.2 metre (4 ft) wide by 1.2 metre (4 ft) high galvanized wire mesh screens with 13 mm (½ in) openings.

The screens become plugged with aquatic vegetation, snails, clams, etc. and are cleaned every 3 to 4 months. The screenings are deposited on the ground near the sludge settling ponds.

.3 Low Lift System

The low lift pump well is cleaned at the same time as the inlet screens. There will usually be a 0.75 metre (2.5 ft) depth of silt build-up in parts of the well. The silt is loosened with a hose stream and pumped to the settling ponds. The three Allis Chalmers horizontal centrifugal pumps have capacities of 5.24 ML/d (1.15 mgd), 7.85 ML/d (1.73 mgd) and 5.24 ML/d (1.15 mgd), all with constant speed electric motors. Low lift pump LL-1 (5.24 ML/d) (1.15 mgd) is in need of an overhaul and is not in operable condition.

Low lift pump LL-2 is the primary duty pump and since it has a capacity larger than the capacity of the intake system, its discharge must be throttled.

Low lift pump LL-3 has a capacity slightly less than the intake system capacity and can operate without the discharge being throttled. Raw water is pumped to the clarifier through approximately 30 m (100 ft) of 400 mm (16 in) diameter pipe. Raw water flow must match the high lift pump discharge flow since there is no storage of clarifier effluent. Raw water flow is adjusted by a gate valve on the low lift pump discharge piping to maintain a proper operating level in the clarifier.

There is no provision for automatically stopping pumps on low level in the pump well.

.4, .5, .6 Clarification

Clarification is accomplished in an 18.3 m (60 ft) diameter by 4.27 m (14 ft) side water depth settling tank in which Eimco solids contact upflow type internals are installed. Clarifier effluent is collected through orifices in submerged radial square tubes which discharge to a circular launder around the outside of the detention cone. Effluent flows into an effluent chamber adjacent to the clarifier and then to the plant building through a 400 mm

(16 in) diameter pipe. The high lift pump suction pipes are connected directly to the clarifier effluent pipe.

Settled sludge is moved to a central hopper by bottom scrapers and the sludge blow down valve is opened for a timed period at various times during the day. On the date of the site inspection, sludge was being blown down for 6 seconds every 3 minutes. The sludge blow down valve is air operated and is located, along with a compressor, in a building immediately north of the clarifier. Sludge is discharged to a settling pond north of the plant where solids are allowed to settle and clear supernatant flows through an interconnecting pipe to the backwash wastewater settling pond.

Settling tests on samples from the sludge hopper, draft tube and mixing chamber are carried out every 4 hours. Samples are allowed to settle for 10 minutes in a 1,000 mL flask. Following are the percentages of settleable solids (by volume) the operators attempt to maintain.

Hopper - 50% to 80%
Draft Tube - 40%
Mixing Chamber - 30%

The results of the settling tests are used to determine the sludge blow down sequence and the turbine speed. The turbine speed will be increased if the sludge in the bottom of the tank or the draft tube is too dense or is too light in the mixing chamber.

Rake speed is changed to ensure stable consistency of sludge in the sludge hopper. The rake speed is changed infrequently.

Floating wooden radial booms have been installed on the surface of the clarifier to reduce the effects of wind which previously would cause floc carry over and a resultant degradation of the clarifier effluent quality.

Air is introduced through diffusers around the tank perimeter and around the outside of the central launder to prevent ice formation.

The timer adjustment for the sludge blow down sequence is too coarse and the operators cannot adjust the sequence to the accuracy they desire.

.7 Filters

The plant has four pressure filters inside the plant. Three are 2.4 metre (8 ft) diameter by 4.9 metres (16 ft) long and the fourth is 3 metres (10 ft) diameter by 7.3 metres (24 ft) long. Two additional filters are installed outside of the plant and have been used for summer flow requirements. These filters are in a state of disrepair and are not in operable condition.

Normally, the four filters inside the building are in operation except when one of them is being backwashed. There are no flow measuring devices on the filter inlet or outlet piping and it is not possible to determine the flow rate through each filter. Filters are backwashed after every 48 hours of operation. Filter backwash water is stored in a 68 m^3 (15,000 gal) elevated tank and the entire tank volume is used for each backwash.

Following is a brief description of backwash procedure:

- Close filter effluent valve.
- Close filter inlet valve.
- Open backwash wastewater valve.
- Slowly open backwash water inlet valve (ie. four turns of the valve stem).
- When wastewater clears, open backwash water inlet valve two more turns.
- Backwash for 10 minutes.
- Close backwash water inlet valve.
- Close backwash wastewater valve.
- Open filter influent valve.
- Open filter effluent valve.

A newly backwashed filter is put into service without any rest period. Although facilities are available to filter to waste, this procedure is not practised. When a filter is backwashed, flow through the other filters increases. Consequently the filter effluent turbidity can increase by as much as 1 FTU on occasion.

Backwash wastewater drains to a settling pond on the north side of the plant where solids settle and clear supernatant drains to the lake.

.8 High Lift Pumping

As noted above there are three high lift horizontal centrifugal pumps.

There is no high lift pump suction well and the pumps' suctions are connected directly to the clarifier effluent pipe. A positive head is maintained by regulating low lift pump discharge to insure a proper water surface elevation is maintained in the clarifier effluent chamber.

High lift pump HL-1 is the primary duty pump. High lift pump HL-2 is operated weekly to test the diesel engine drive. High lift pump HL-3 is not in operable condition.

There are no provisions for automatically stopping the pumps on low suction pressure conditions. However, an alarm alerts the operator when this condition occurs.

D.4 Chemicals

(i) Coagulant

Prior to February 1986, liquid alum was used as a coagulant. Polyaluminum chloride has been used since that time.

Coagulant is stored in a 23 cubic metre (5,000 gal) outdoor heat traced and insulated fiberglass storage tank. Coagulant is fed to the low lift discharge header by a diaphragm metering pump. Coagulant dosage is generally adjusted on the basis of raw water turbidity. The plant has a chart (see Appendix A) which gives coagulant dosage requirements for different raw water conditions. This information is used as a guide in selecting coagulant dosage and jar tests are done when previous experience or use of the guideline does not produce satisfactory results. A calibration chamber connected to the coagulant feed pump suction piping is used to calibrate the feed pump once per day.

Coagulant dosage rates are changed manually and because the feed pump is not interlocked with the low lift pumps, it must be turned on and off manually when the low lift pump is turned on or off.

The average coagulant dosage is calculated daily from the measured amount of coagulant used and the daily plant flow.

(ii) Coagulant Aid

Although a storage tank and diaphragm metering pump are available for feeding coagulant aid, coagulant aid is not presently used.

(iii) Fluoride

Fluoridation is accomplished by feeding a sodium fluoride solution to the clarifier effluent pipe (ie. high lift pump suction header). The sodium fluoride solution is produced in a saturator which has a pipe manifold collection system embedded in the bottom of a layer of granular material on top of which granular sodium fluoride (97% NaF) is added. Soft water is added to the saturator tank through a solenoid valve which is activated by a float switch to maintain a proper operating level.

The metering pump feed rate is adjusted manually to maintain a fluoride ion residual of 1.2 mg/L in the plant effluent.

The saturator is charged with 9.08 kg (20 lb) of sodium fluoride daily. The daily dosage is calculated based on the volume of water treated and 9.08 kg (20 lb) of sodium fluoride even though the exact consumption of the sodium fluoride is not determined.

The plant superintendent indicates it is difficult to maintain proper residuals with the existing fluoridation system. The openings in the manifold become plugged and the media and the manifold orifices have to be cleaned every two months. Because of the intensive maintenance, the potential hazard to staff and problems in disposing of debris removed during cleaning of the equipment, it has been decided to replace the system with one using fluoride in liquid form.

(iv) Taste and Odour Control (Chlorine Dioxide)

Chlorine dioxide is produced by mixing solutions of chlorine and sodium chlorite and is fed to the low lift pump discharge header. Although chlorine dioxide is in itself a disinfectant, the excess of chlorine normally used in its generation, rather than the chlorine dioxide, is generally counted on to accomplish disinfection. This appears to be the case at the Tilbury Plant since the chlorine dioxide system was operated with sufficient excess chlorine to maintain a free chlorine residual of 1.0 mg/L in the clarifier effluent. The sodium chlorite feed rate is never adjusted.

(v) Disinfection (Post-Chlorination)

Chlorine solution is added to the clarifier effluent pipe (ie. high lift pump suction header) at a feed rate to maintain 1.5 mg/L free chlorine residual in the plant effluent.

D.5 Process Automation

The only automated feature in the plant is the clarifier sludge blow down sequence.

None of the motors are interlocked with each other and when the plant is shut down either because of a high level in the Town's storage reservoir or when the plant is shut down for a normal non-production day, each motor has to be stopped manually.

SECTION E
PLANT PERFORMANCE

E.1 Particulate Removal

During 1987, raw water turbidity averaged 40 FTU, ranging from a minimum daily average of 3 FTU to a maximum of 505 FTU. Maximum hourly measurements could reach 3000 FTU.

The following table gives the time distribution of raw water turbidity:

Raw Water Turbidity (1987)
(Daily average)

Turbidity (FTU) Equal to or less than	Percent of time
505	100
400	99
200	97
100	92
50	82
20	56
10	36
5	13

Since clarifier effluent turbidity records are not available, it is not possible to evaluate clarifier effectiveness. For 1987 coagulant dosages (polyaluminum chloride) were:

Minimum	-	5.5 mg/L
Maximum	-	101 mg/L
Average	-	18.4 mg/L

During 1987 (March-December), treated water turbidities were:

Minimum	-	0.01 FTU
Maximum	-	1.30 FTU
Average	-	0.13 FTU

Distribution of treated water turbidities is given in the following table.

Treated Water Turbidity (1987)

Turbidity (FTU) equal to or less than	**Percent of time**
1.30	100
1.00	99
0.80	98
0.50	97
0.40	95
0.30	92
0.20	87
0.10	71

Treated water turbidity exceeded the Ontario Drinking Water Objective of 1 FTU on only 2 days during 1987. A review of the operating data generally indicates high treated water turbidity during periods of cold water and higher raw water turbidities. In general, particulate removal is very good. It should be noted, however, that the sampling line at the velocity of 0.03 m/sec (0.1 ft/sec) and 20 minute retention time could act as a highly efficient settling tank.

E.2 Disinfection

Plant practice is to post-chlorinate the clarifier effluent to maintain a 1.5 mg/L free chlorine residual in the plant effluent.

During 1986 and 1987, daily free chlorine residual in the plant effluent varied from 0.10 mg/L to 4.38 mg/L. Chlorine dosages varied from 0.34 mg/L to 6.20 mg/L.

Table 3.1 Disinfection Profile indicates that, in many instances, the free chlorine residual in the plant effluent is lower than the free residual in the clarifier effluent in spite of post chlorination. This discrepancy is difficult to understand and cannot be readily explained.

Bacteriological test results for March-December 1987 have all been negative which indicates effective disinfection is being accomplished.

SECTION F
RECOMMENDATIONS

As noted earlier, the plant superintendent has been employed at the plant for approximately one year and continues to make changes in operating procedures etc. to improve the efficiency of the plant.

The Tilbury Public Utilities Commission has recently awarded a contract for carrying out a number of improvements at the plant as follows:

- Construction of a 227 m^3 (50,000 gal) reinforced concrete backwash water storage tank at the plant. New high lift pumps will be installed in the future. The present contract includes installation of a filter backwash water pump to replace the existing elevated backwash water storage tank. This will allow much improved filter backwashing.

- Installation of an ultrasonic level sensing instrument on the clarifier level indicating sight glass and an automatic control valve in the low lift pump discharge header. This system will automatically maintain a proper clarifier water surface elevation.

- Replacement of the plant output flow meter (ie. buried venturi). The new meter will be 300 mm (12 in) dia. Rockwell propeller meter installed in a chamber inside the plant. Flow will be indicated and recorded on a circular chart recorder.

- Installation of an orifice plate, flow indicator/controller and butterfly valve in each filter inlet pipe . The system will allow the operator to set the desired filter flow rate and the butterfly valve will be adjusted automatically to maintain the preset filter flow rate.

The Tilbury Public Utilities Commission has received recommendations from its consulting engineer for a new intake and plant capacity expansion and accordingly only short term solutions to improve plant operation are given below.

.1 Pump Suction Protection

There are no provisions for stopping the low lift pumps or high lift pumps if the levels in the low lift pump well or high lift pump suction header are low.

It is recommended that level sensing instruments be installed to either automatically stop the pumps or sound an alarm if pump suction water levels are low.

.2 Turbidity Measurements

In general it is recommended that the minimum velocity in a turbidity sampling line be maintained at 1.0 m/sec (3 ft/sec).

a) Raw Water

The plant has a continuous raw water turbidity measuring system. It is recommended that a recorder, with alarm capabilities, be provided for raw water turbidity.

b) Filter Effluent

Filters are backwashed on the basis of filter run time (ie. every 48 hours). Particulate removal could probably be improved if filter effluent turbidity was also used as a factor to determine the backwash schedule.

It is recommended that a continuous flow-through turbidimeter be installed on each filter effluent. The sampling cells should be installed close to the sampling location to reduce the sample flow time to the measuring instrument. Turbidity indicators could be installed remotely in the laboratory and audible alarms provided to alert the operator of high turbidity.

c) **Clarifier Effluent**

The clarifier is presently uncovered and subject to upset due to wave action and freezing. The clarifier should be covered.

Because the plant does not have settled or treated water storage, an increase in settled water turbidity could result in an almost immediate increase in plant effluent turbidity.

To limit the effect of increased settled water turbidity, it is recommended that a continuous flow turbidimeter be installed on the clarifier effluent. The flow velocity in the line to the sample cell should be high enough to avoid settling in the sample line and provide minimum sample travel time. The turbidity indicator could be installed in the laboratory and be connected to the plant alarm system. Settled water turbidity should be recorded on the log sheets on a regular basis to monitor treatment effectiveness.

d) **Plant Effluent**

The sample flow time to the existing plant effluent turbidimeter is excessive and it is recommended to increase the sample flow rate or relocate the sample cell to a point closer to the sample source.

In order to monitor plant effluent turbidity 24 hours per day it is recommended that a circular chart recorder be provided for effluent turbidity.

.3 **Chlorination**

a) **Scales**

The plant does not have chlorine scales.

It is recommended that a chlorine scale be provided to allow accurate measurement of chlorine usage. Ideally, separate scales should be provided for determining chlorine consumption for chlorine dioxide generation and post chlorination.

b) **Chlorine Dioxide System**

The chlorine dioxide system relies on the use of excess chlorine to produce chlorine dioxide and test results indicate the presence of fairly high concentrations of trihalomethanes in the finished water.

It is recommended that the need for taste and odour control be reevaluated and if found necessary consider:

(i) Discontinuing the use of chlorine dioxide in favour of alternate means of taste and odour control (ie. activated carbon).

(ii) Modify chlorine dioxide system by using an acid for pH adjustment instead of excess chlorine.

(iii) Implement a program for monitoring chlorine dioxide residuals.

(iv) Request MOE to provide training in the correct operation of chlorine dioxide systems.

c) **Equipment Layout and Piping**

The standby chlorinator is connected in such a manner that it can be used for chlorine dioxide generation but not for post chlorination. The chlorine room is very small and the piping system seems overly complex and has unnecessary fittings.

It is recommended that the chlorination system be reworked to produce a neat and orderly arrangement of equipment and piping using a minimum number of fittings to reduce the potential for leakage and to allow use of the standby chlorinator for post-chlorination.

d) Chlorine Residual Analyzer

A chlorination system failure would result in the almost immediate discharge of non-disinfected water to the distribution system.

It is recommended that a chlorine residual analyzer/ recorder with alarm points be installed to monitor plant effluent free chlorine residual. In addition total chlorine residuals should be measured and recorded in the daily log sheets.

.4 Pipeline Identification

It is recommended that all piping (especially chemical lines) be colour coded or otherwise identified and be provided with direction of flow arrows.

.5 Filter Operation

a) Filter Backwash

When a filter is taken out of service for backwashing, the flow to the other filters increases which results in increased effluent turbidity.

The new filter flow control system will correct this problem although the flow to a filter to be backwashed should be reduced slowly to allow time for the control system on the other filters to react.

b) **Filter to Waste**

It is recommended that filter effluent testing be carried out to document the effluent turbidity profile of a newly backwashed filter to determine if filtering-to-waste would be beneficial.

.6 **Coagulant Dosage Control**

It is recommended that a **streaming current meter** be obtained for a trial period to determine if the use of such a device would be beneficial.

.7 **Plant Security**

The plant is in an isolated area and could be the subject of vandalism and/or sabotage when staff is not at the plant.

Although it would be difficult to provide fail-safe protection, consideration could be given to installing intrusion alarms or other means of protecting the premises.

.8 **Operator Safety Alarm**

An operator is on duty alone for 24 hours and if he became immobilized through sickness or injury his problem could possibly go unnoticed for a lengthy period of time.

It is recommended that a system be installed to verify the operator's well being. Such a system could be comprised of an audible alarm at the plant every 30 minutes which, if not cancelled by the operator within 15 minutes, would cause a signal to be sent to a security company alarm panel or other continuously manned location.

.9 Raw Water Flow Measurement

At the present time pretreatment chemical dosages are based on treated water flow.

Since modifications will be made to the raw water flow system, provision for a raw water flow indication could be considered, as well as automatic chemical feed pacing.

.10 Operating Manual

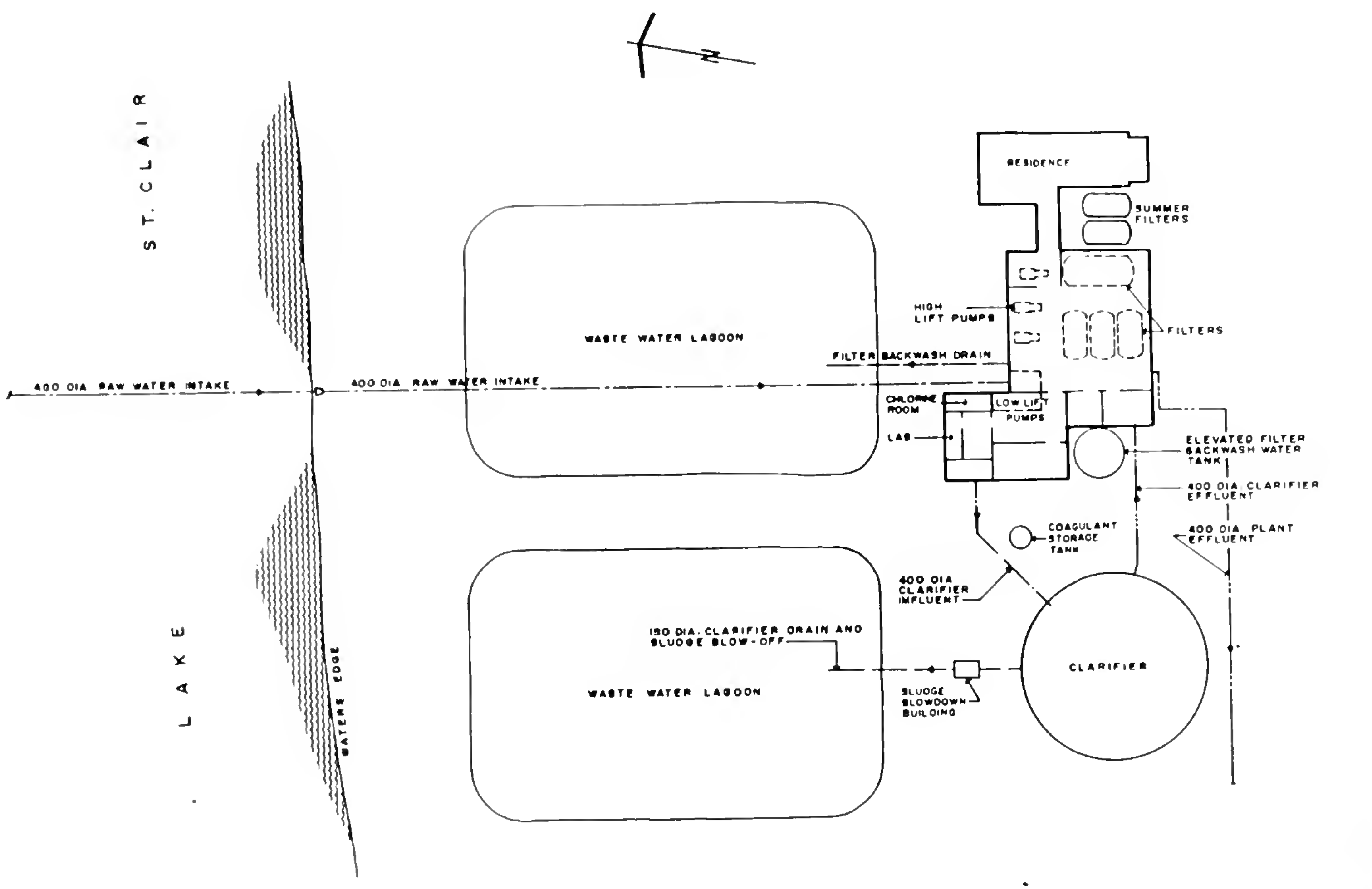
Due to 1) the nearly total manual operation of this plant,
2) the frequent process control and equipment changes made since the plant was commissioned and
3) the potential for staff turnover,

it is highly recommended that an operation manual be produced.

.11 Drinking Water Surveillance Program

It is recommended that the Tilbury Water Treatment Plant be included in the Ministry's Drinking Water Surveillance Program.

APPENDIX A



WATER PLANT
OPTIMIZATION STUDY

MOE Project N° 7-2032

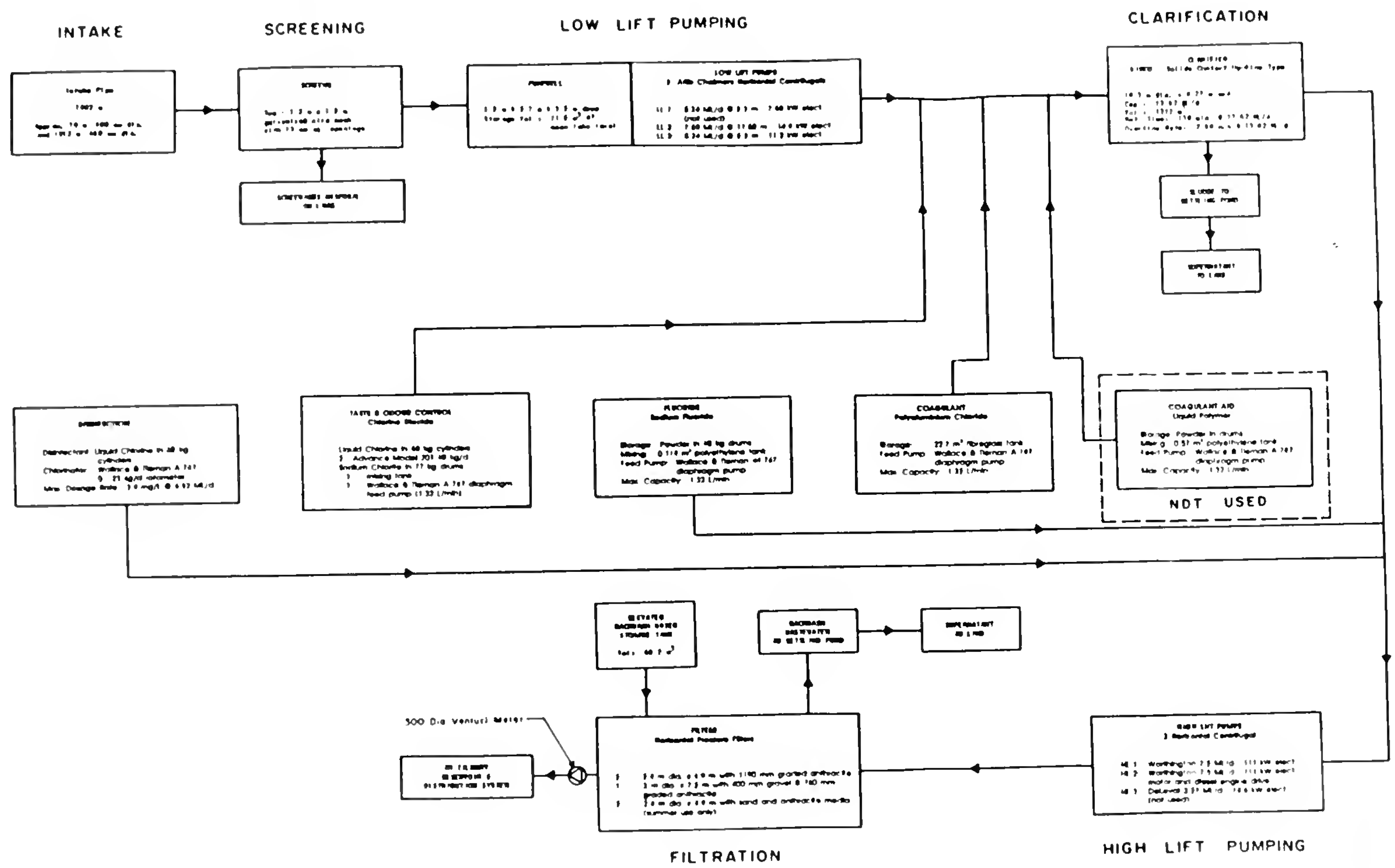
TILBURY
WATER TREATMENT PLANT

SITE PLAN

SCALE - METRES

LA FONTAINE, COWIE, BURATTO & ASSOCIATES LIMITED

Date	88 03 03
File N°	WR 158 T
Figure N° 3	



WATER PLANT
OPTIMIZATION STUDY

MOE Project N° 7-2032

TILBURY
WATER TREATMENT PLANT

BLOCK SCHEMATIC

LaFONTAINE, COWIE, BURATTO & ASSOCIATES LIMITED

Date 88 03 03

File N° WR 158

Figure N° 4

THE EIMCO TYPE HR SOLIDS CONTACT
REACTOR CLARIFIER
OPERATING DIAGRAM

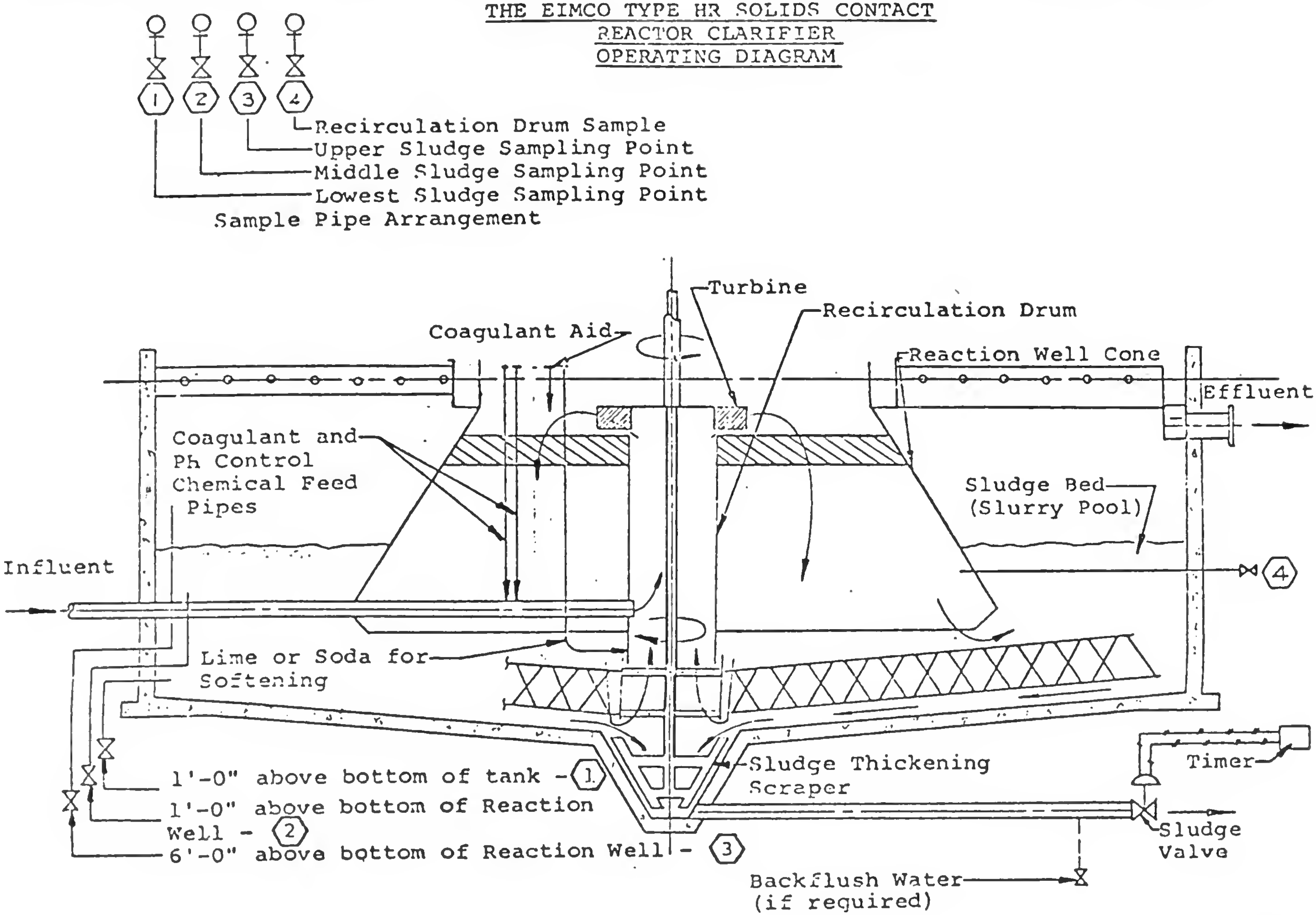


Figure N° 5

APPENDIX B

Plant Data Recording Sheets

Plant Start-up/ Shut-down Procedures

Primary Coagulant Dosage Chart

UTILITY MONITORING SYSTEM

Water Treatment Plant

Municipality ______________________

Project Name ______________________

Project Number ______________ Month ______________ Year ______

Project Location ______________________

Superintendent/Chief Operator ______________________

Enter comments on the back of this page.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Backwash #1																																
#2																																
#3																																
#4																																
Residual Pre. 7																																
9																																
11																																
13																																
15																																
17																																
19																																
21																																
23																																
01																																
03																																
05																																
Residual Fst. 7																																
9																																
11																																
13																																
15																																
17																																
19																																
21																																
23																																
03																																
07																																
09																																
Fluoride a.m.																																
p.m.																																
FAD gals.																																
Fluoride kg																																
Softening salt																																

*RECORD FLOW ACTUALLY LEAVING PLANT

DAILY WORK SHEET

MONTH ____________ 19____

	INTEG.X100		PH		TURBIDITY				CHLORINE		CHLORINE		SODIUM CHL	PAC
PREV		HRS PUMP	RAW	TREATED	RAW	TREATED	MAX	TEMP.	PRE FEED	RESID	POST FEED	RESID	LBS	ml/MIN
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														
21														
22														
23														
24														
25														
26														
27														
28														
29														
30														
31														

PROCESS MONITORING DATA
TILBURY WATER TREATMENT PLANT

				pH			RPM		SET SOLIDS				TURBIDITY NTU								
	DATE	TIME	TEMPC	R	T	DOS	RAKE	TURBINE	2	3	4	5	RAW	CLEFF	F1	F2	F3	F4	F5	F6	PLEFF
1																					
2																					
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					
11																					
12																					
13																					
14																					
15																					
16																					
17																					
18																					
19																					
20																					
21																					
22																					
23																					
24																					
25																					
26																					
27																					
28																					
29																					
30																					
31																					
32																					
33																					
34																					
35																					
36																					
37																					
38																					
39																					
40																					

REVISED: APRIL 16, 1989. PLANT START UP

1a. START LOW LIFT PUMP

A. PRIME IF NEEDED

B. TURN ON THE '3/4 IN. WATER VALVE LOCATED ABOVE THE PUMP THAT YOU ARE PRIMING

C. OPEN VALUTE BLEEDER VALVE UNTIL ALL AIR HAS BEEN EXPELLED THEN TURN IT OFF

D. TURN ON THE PACKING WATER LINE UNTIL CONTINUOUS DRIP

E. PUSH THE START BUTTON

1b SPECIAL PRIMING PROCEDURE
IN THE EVENT OF THE FOOT VALVE NOT SEATING PROPERLY

A. START LOW LIFT PUMP #3 USING THE PROCEDURE IN 1A.

B. TURN ON PACKING WATER LINE TO PUMP #2

C. OPEN DISCHARGE VALVE OF PUMP #2 UNTIL THE SHAFT SPINS BACKWARDS

D. OPEN THE VALUTE BLEEDER VALVE UNTIL ALL AIR HAS BEEN EXPELLED THEN TURN IT OFF

E. QUICKLY TURN OFF THE DISCHARGE VALVE PUMP #2

F. WAIT UNTIL SHAFT STOPS TURNING AND PUSH THE START BUTTON

G. SLOWLY OPEN THE PUMP #2 DISCHARGE VALVE

H. SHUT DOWN LOW LIFT #3

I. IF PUMP FAILS TO START REPEAT STEPS A TO H

2. START HIGH LIFT PUMP #1 OR #2

A. THE STANDBY PUMP MUST HAVE THE SUCTION VALVE CLOSED WHILE THE OTHER PUMP IS OPERATING.

B. OPEN INLET VALVE ON PRIMARY PUMP IF IT IS CLOSED. THEN OPEN THE DISCHARGE VALVE

C. TURN SWITCH ON THE NORTH WALL TO THE ON PUMPING POSITION (THIS SWITCH OPERATES THE VALVE AT THE RESERVOIR IN TILBURY)

D. MONITOR PUMP GAUGE PRESSURE . WHEN THE PRESSURE STARTS TO DROP START THE PUMP

E. CHECK FLOW RATE L/S TO INSURE PROPER PUMPING .

3. CHEMICAL FEEDS

A. OPEN WATER VALVE TO CHLORINATORS

B. IN THE CHLORINE ROOM OPEN CHLORINE CYLINDER VALVES

C. MAKE SURE CHLORINE IS BEING FED BY OBSERVING ROTAMETERS

D. TURN ON CHEMICAL FEED PUMPS (FOUR)
   1. POY-ALUMINUM-CHLORIDE (PAC)
   2. SODIUM FLUORIDE
   3. AQUA MAG (PHOSPHATE)
   4. CARBON WHEN IN USE.

4. LAB

A. TURN ON CLARIFIER SAMPLE TAPS

B. TURN ON SLUDGE VALVE IF NEEDED

C. SWITCH ON LAB INSTRUMENTS
   1. FLUSH OUT RAW WATER SAMPLE LINE APPROX. HALF THE PAIL BEFORE DIRECTING IT THE THE METER. THEN SWITCH ON THE INSTRUMENT.
   2. LOW RANGE TURBIDITY METER AND CHART .
   3. X/R TURBIDITY RATIO BENCH METER MODEL.

5. MONITOR LOW LIFT WELL LEVEL AND CLARIFIER LEVEL
THROTTLE LOW LIFT OR HIGH LIFT VALVES WHEN REQUIRED
TO MAINTAIN DESIRED LEVELS

REVISED: APRIL 15, 1989 PLANT SHUT DOWN

1. CHEMICAL FEEDS

A. TURN OFF ALL CHEMICAL FEED PUMPS (4)
   1. POLY-ALUMINUM-CHLORIDE
   2. SODIUM FLUORIDE
   3. SODIUM PHOSPHATE (AQUA-MAG)
   4. CARBON WHEN IN USE.
B. TURN OFF CHLORINE CYLINDER VALVES .
C. OBSERVE THE CHLORINATOR ROTAMETERS THAT THE GLASS BALLS DROP TO THE BOTTOM WHICH WILL INDICATE NO FEED.
D. TURN OFF WATER VALVES TO CHLORINATORS

2. SHUT DOWN LOW LIFT

A. PUSH THE STOP BUTTON ON THE CONTROL PANEL
B. OBSERVE PUMP SHAFT ROTATION IT COME TO A COMPLETE STOP. IF IT IS SPINNING BACKWARDS THE FOOT VALVE DID NOT SEAT PROPERLY IF THIS HAPPENS TURN OFF THE PUMP DISCHARGE VALVE (note special priming procedure on the start up instructions)

3. SHUT DOWN HIGH LIFT

A. TURN THE NORTH WALL SWITCH TO THE OFF PUMPING POSITION
B. SLOWLY THROTTLE THE HIGH LIFT DISCHARGE VALVE WHILE THE LINE PRESSURE BUILDS UP FROM THE TOWER
C. PUSH THE STOP BUTTON ON THE CONTROL PANEL

4. LAB

A. TURN OFF CLARIFIER SAMPLE TAPS
B. SWITCH OFF SLUDGE VALVE IF IT IS OPERATING
C. SWITCH OFF LAB INSTRUMENTS
   1. SURFACE SCATTER TURBIDITY METER AND WATER SUPPLY LINE
   2. LOW RANGE TURBIDITY METER AND CHART IF MONITORING
   3. X/R TURBIDITY RATIO BENCH METER ONLY FOR LONG SHUT DOWN PERIODS.

M E M O R A N D U M   August 03, 1990.

TO: ALL PLANT STAFF
TILBURY WATER TREATMENT PLANT

FROM: Gaston Bouillon
Chief Operator
Tilbury Water Treatment Plant

RE: SHUT DOWN PROCEDURE

Please be advised that we must shut down the plant in the following manner.

1. Shut down the low lift , the metering pump and the chlorine in the usual way.

2. The high lift pump must be throttled down to 40 psi on the pressure gauge by filter # 1.

3. Turn the wall switch to the off pumping position, when the pressure rises again turn off the high lift pump.

Thank you.

Gaston Bouillon

Gaston Bouillon

REFERENCE CHART FOR STERNPAC

Liquid sternPac = 33.40%Active Ingredient

Specific Gravity = 1.2

1 litre of sternPac weighs 1200 grams

1 litre of sternPac contains 400 gms of active ingredient
or
0.4 kgs of active ingredient
or
1 Imp. gallon weighs 12 lbs 4 lbs per imperial gallon of active ingredient

Use the following dosage rates as a guide.

NTU	PAC DOSAGE
15 - 40	12
40 - 60	14
60 - 100	18
100 - 140	20
140 - 170	23
170 - 220	27

A jar test should be used to fine tune the dosage rate .

Also for turbidity ranges higher than the ones above a jar test should be performed.

To calculate ml/min of sternPac required:

$$\frac{\text{mg/l dosage required} \times \text{Flow rate in 1000m3}}{.575} = \text{ml/min.}$$

APPENDIX C

Tables 1.0 to 3.1

WATER PLANT OPTIMIZATION STUDY
TILBURY WATER TREATMENT PLANT

TABLE 1.0: FLOWS (ML/d)

		1987			1986			1985		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JAN	R									
	T	5.94	1.74	4.90	6.18	3.54	4.68	6.25	2.21	4.31
FEB	R									
	T	6.81	3.48	5.23	5.15	0.89	4.43	5.87	1.11	4.22
MAR	R									
	T	6.71	3.47	3.65	5.81	3.39	4.67	5.50	1.28	3.77
APR	R									
	T	6.78	2.08	4.03	6.06	1.28	3.72	6.31	1.80	4.29
MAY	R									
	T	6.66	3.15	4.83	6.50	1.55	4.41	6.81	1.39	4.44
JUN	R									
	T	6.67	3.53	5.28	6.24	2.30	4.38	6.92	1.61	4.29
JUL	R									
	T	5.16	2.80	4.16	5.54	2.76	3.79	6.37	1.23	3.91
AUG	R									
	T	7.19	2.95	6.14	6.93	2.76	5.60	6.30	1.29	4.98
SEP	R									
	T	7.19	3.27	5.80	6.97	2.36	5.80	6.44	3.19	5.57
OCT	R									
	T	6.83	2.34	4.39	6.41	1.99	4.33	6.22	1.41	4.01
NOV	R									
	T	5.02	2.37	4.02	6.59	3.74	5.20	6.10	1.16	3.69
DEC	R									
	T	4.58	1.48	3.44	5.80	2.87	4.75	6.25	3.03	4.38

R - RAW ; T - TREATED

TABLE 2.0: PARTICULATE REMOVAL SUMMARY

	PARAMETER			1987			1986			1985			1984		
				MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JAN	Turbidity	(FTU)	R	133.00	8.00	35.00	108.00	8.00	30.20						
			T												
	Colour	(TCU)	R												
			T												
	Prime Coagulant	(mg/L)		22.5	5.51	10.69	44.80	31.80	35.50						
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	7.80	7.40	7.64	7.90	7.60	7.80						
			T	7.30	6.90	7.10	7.50	7.30	7.38						
	Temperature*	(Deg.C.)		3.00	1.00	2.00	2.00	1.00	1.20						
FEB	Turbidity	(FTU)	R	8.00	3.00	5.40	80.00	8.00	47.20						
			T												
	Colour	(TCU)	R												
			T												
	Prime Coagulant	(mg/L)		7.23	5.25	5.76	70.50	24.70	45.60						
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	7.70	7.40	7.60	7.90	7.60	7.70						
			T	7.50	7.10	7.20	7.50	7.20	7.40						
	Temperature*	(Deg.C.)		2.00	1.00	1.10	2.00	1.00	1.20						

Prime Coagulant: Liquid Alum Jan & Feb 1986
Polyaluminlun Chloride Mar 1986 - Dec 1987

Temperature: Treated Water - Jan 1986 to Feb 1987 inclusive
Raw Water - Mar to Dec 1987

TABLE 2.0: PARTICULATE REMOVAL SUMMARY

	PARAMETER			1987			1986			1985			1984		
				MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
MAR	Turbidity (FTU)		R	160.00	4.00	43.50	400.00	11.00	105.00						
			T	1.3	0.03	0.26									
	Colour (TCU)		R												
			T												
	Prime Coagulant	(mg/L)		33	7.5	16.9	53.9	14.3	26.7						
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	8.00	7.30	7.62	7.80	7.50	7.70						
			T	7.60	7.00	7.20	7.40	7.10	7.30						
	Temperature*	(Deg.C.)		9.00	1.00	3.50	8.00	1.00	2.30						
APR	Turbidity (FTU)		R	90.00	8.00	37.00	200.00	8.00	63.00						
			T	76	0.01	0.18									
	Colour (TCU)		R												
			T												
	Prime Coagulant	(mg/L)		101	19	26.4	44.4	11.2	29.4						
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	8.40	6.60	7.60	8.30	7.60	7.90						
			T	7.90	6.60	7.10	7.60	6.80	7.30						
	Temperature*	(Deg.C.)		15.00	4.00	9.90	13.00	5.00	8.30						

Temperature: Treated Water - Jan 1986 to Feb 1987 inclusive
Raw Water - Mar to Dec 1987

TABLE 2.0: PARTICULATE REMOVAL SUMMARY

	PARAMETER			1987			1986			1985			1984		
				MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
MAY	Turbidity	(FTU)	R	33.00	3.00	12.70	130.00	9.00	44.00						
			T	0.45	0.02	0.09									
	Colour	(TCU)	R												
			T												
	Prime Coagulant	(mg/L)		30	17	24	15.9	0.9	6.3						
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	8.60	7.50	8.10	8.40	7.30	7.90						
			T	8.10	7.00	7.60	7.60	7.20	7.40						
	Temperature*	(Deg.C.)		23.00	12.00	16.40	21.00	11.00	15.10						
JUN	Turbidity	(FTU)	R	36.00	4.00	13.20	260.00	12.00	72.90						
			T	0.8	0.02	0.13									
	Colour	(TCU)	R												
			T												
	Prime Coagulant	(mg/L)		18.7	11	35	14.2	2.7	8.5						
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	8.30	7.10	7.90	7.90	7.50	7.80						
			T	7.80	7.00	7.30	7.60	7.00	7.20						
	Temperature*	(Deg.C.)		27.00	19.00	23.30	23.00	19.00	20.80						

Temperature: Treated Water - Jan 1986 to Feb 1987 inclusive
Raw Water - Mar to Dec 1987

TABLE 2.0: PARTICULATE REMOVAL SUMMARY

	PARAMETER			1987			1986			1985			1984		
				MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JUL	Turbidity (FTU)		R	85.00	5.00	10.60	80.00	7.00	36.20						
			T	0.13	0.03	0.05									
	Colour (TCU)		R												
			T												
	Prime Coagulant	(mg/L)		17.9	13.2	15.32	8.1	3.7	5.57						
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	8.20	7.40	7.80	7.90	7.40	7.80						
			T	7.40	6.80	7.24	7.50	6.80	7.30						
	Temperature*	(Deg.C.)		29.00	23.00	26.40	27.00	22.00	24.80						
AUG	Turbidity (FTU)		R	42	4.00	12.30	80.00	15.00	31.70						
			T	0.4	0.03	0.12									
	Colour (TCU)		R												
			T												
	Prime Coagulant	(mg/L)		31	12	17	7.6	3.5	5						
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	7.9	7.40	7.70	7.90	7.60	7.80						
			T	7.3	6.90	7.10	7.50	7.10	7.30						
	Temperature*	(Deg.C.)		28	24.00	26.00	26.00	19.00	23.60						

Temperature: Treated Water - Jan 1986 to Feb 1987 inclusive
Raw Water - Mar to Dec 1987

TABLE 2.0: PARTICULATE REMOVAL SUMMARY

Month	Parameter	Unit	R/T	1987 MAX.	1987 MIN.	1987 AVG.	1986 MAX.	1986 MIN.	1986 AVG.	1985 MAX.	1985 MIN.	1985 AVG.	1984 MAX.	1984 MIN.	1984 AVG.
SEP	Turbidity (FTU)		R	140.00	6.00	36.00	90.00	15.00	44.10						
			T	0.35	0.03	0.11									
	Colour (TCU)		R												
			T												
	Prime Coagulant	(mg/L)		26.8	12.9	19.2	7.8	4.1	4.9						
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	8.20	6.70	7.70	7.90	7.40	7.70						
			T	7.50	7.00	7.20	7.30	7.00	7.20						
	Temperature*	(Deg.C.)		25.00	21.00	22.60	22.00	17.00	18.90						
OCT	Turbidity (FTU)		R	130.00	14.00	44.70	300.00	17.00	78.00						
			T	0.12	0.02	0.06									
	Colour (TCU)		R												
			T												
	Prime Coagulant	(mg/L)		22	11.7	15	23.3	5.4	10.2						
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	8.00	7.00	7.60	8.20	7.10	7.60						
			T	7.60	7.00	7.20	7.50	7.00	7.20						
	Temperature*	(Deg.C.)		19.00	10.00	12.80	22.00	8.00	13.90						

Temperature: Treated Water - Jan 1986 to Feb 1987 inclusive
Raw Water - Mar to Dec 1987

TABLE 2.0: PARTICULATE REMOVAL SUMMARY

Month	Parameter	Units		1987 MAX.	1987 MIN.	1987 AVG.	1986 MAX.	1986 MIN.	1986 AVG.	1985 MAX.	1985 MIN.	1985 AVG.	1984 MAX.	1984 MIN.	1984 AVG.
NOV	Turbidity (FTU)		R	139.00	8.00	33.60	135.00	14.00	51.30						
			T	0.9	0.02	0.1									
	Colour (TCU)		R												
			T												
	Prime Coagulant	(mg/L)		20	11.3	13.8	14.4	6.8	9.4						
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	7.90	6.80	7.30	8.20	7.70	7.70						
			T	7.30	6.50	7.10	7.70	7.20	7.40						
	Temperature*	(Deg.C.)		11.00	4.00	7.90	12.00	4.00	6.70						
DEC	Turbidity (FTU)		R	505.00	30.00	181.20	230.00	11.00	68.30						
			T	0.57	0.07	0.22									
	Colour (TCU)		R												
			T												
	Prime Coagulant	(mg/L)		39.7	12	25.1	27	9	14.1						
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	7.60	7.10	7.40	7.90	7.40	7.70						
			T	7.30	6.70	7.10	7.60	7.00	7.30						
	Temperature*	(Deg.C.)		7.00	3.00	4.50	5.00	1.00	2.50						

Temperature: Treated Water - Jan 1986 to Feb 1987 inclusive
Raw Water - Mar to Dec 1987

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JANUARY 1987)

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT *	COAG. AID	(1) PAC	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Treat
1																	
2	14.00	5.00					35.24									7.30	1.0
3	16.00	4.00					34.94									7.40	2.0
4																	
5	18.00	5.00					36.10									7.30	2.0
6	12.00	3.00					33.63									7.40	1.0
7																	
8	10.00	4.00					33.36									7.40	1.0
9	13.00	4.00					32.80									7.40	1.0
10																	
11	12.00	4.00					33.14									7.40	1.0
12	10.00	3.00					32.64									7.50	1.0
13																	
14	8.00	4.00					33.04									7.40	1.0
15	13.00	4.00					33.51									7.40	1.0
16																	
17	15.00	4.00					33.30									7.40	2.0
18	12.00	4.00					31.78									7.40	1.0
19																	
20	16.00	5.00					34.00								7.6	7.50	1.0
21	108.00	8.00					33.51								7.8	7.30	1.0
22																	
23	70.00	10.00					44.83								7.8	7.40	1.0
24	105.00	5.00					43.09								7.8	7.30	1.0
25																	
26	60.00	7.00													7.8	7.30	1.0
27	48.00	17.00					44.80								7.9	7.40	1.0
28																	
29	35.00	8.00					37.54									7.30	1.0
30	10.00						33.61									7.40	1.0
31																	

* Liquid Alum

WATER PLANT OPTIMIZATION STUDY
TILBURY WATER TREATMENT PLANT

TABLE 2.1: PARTICULATE REMOVAL PROFILE (APRIL 1986)

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT *	COAG. AID	(1) PAC	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Treat
1																	
2	60.00	5.00					31.62								7.80	7.30	5.0
3	20.00	3.00					27.14								7.90	7.40	
4																	
5	45.00	18.00					33.94								7.90	7.40	5.0
6	32.00	5.00					36.16								7.90	7.30	9.0
7	25.00	12.00					30.98								7.90	7.30	8.5
8	57.00	14.00					34.47								8.00	7.40	8.0
9	140.00	8.00					44.36								8.00	7.50	10.0
10	100.00	8.00					43.17								7.80	7.30	10.0
11	160.00	17.00					36.47								8.00	7.40	8.0
12	68.00	1.00					35.82								8.10	7.40	6.0
13																	
14	62.00	5.00					37.63								7.80	7.20	7.0
15	12.00	3.00					36.16								7.60	6.80	7.0
16	80.00	5.00					33.22								8.00	6.80	7.0
17	90.00	18.00					28.67								7.90	7.30	7.0
18	24.00	7.00					21.79								7.80	7.10	8.0
19																	
20	50.00	7.00					21.21								8.10	7.30	8.0
21	78.00	4.00					35.19								8.00	7.40	10.0
22	200.00	3.00					34.34								7.90	7.40	8.0
23	70.00	8.00					36.27								7.90	7.30	8.0
24	12.00	4.00					24.31								7.90	7.30	8.0
25	75.00	0.00					23.38								7.80	7.30	9.0
26	50.00	4.00					24.02								8.00	7.40	9.0
27	8.00	8.00					19.42								8.00	7.30	9.0
28	19.00	5.00					11.24								8.20	7.40	9.0
29	65.00	4.00					11.67								8.00	7.30	11.0
30	35.00	3.00					11.93								8.30	7.60	13.0
31																	

* Polyaluminium chloride

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JULY 1986)

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT *	COAG. AID	(1) PAC	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Treat
1	40.00	5.00					8.08								7.70	7.20	23.0
2	22.00	7.00					7.55								7.80	7.20	22.0
3	40.00	7.00					7.74								7.70	7.30	22.0
4	40.00	6.00					6.91								7.80	7.20	22.0
5	23.00	6.00					6.31								7.80	7.20	22.0
6	18.00	6.00					5.47								7.90	7.30	23.0
7	40.00	6.00					5.57								7.80	7.10	23.0
8	38.00	7.00					5.52								7.80	7.20	23.0
9	50.00	7.00					5.59								7.80	7.40	26.0
10	30.00	6.00					5.78								7.90	7.30	25.0
11	35.00	7.00					5.82								7.90	7.30	25.0
12	48.00	9.00					5.99								7.80	7.40	23.0
13	60.00	8.00					5.76								7.70	7.30	23.0
14	80.00	8.00					5.48								7.80	7.30	23.0
15	65.00	9.00					5.64								7.80	7.40	25.0
16	48.00	7.00					5.73								7.70	7.30	24.0
17	40.00	7.00					5.70								7.60	7.40	25.0
18	30.00	10.00					5.64								7.80	7.30	26.0
19	32.00	8.00					5.72								7.70	7.30	27.0
20	33.00	8.00					5.62								7.70	7.30	27.0
21	29.00	7.00					5.65								7.70	7.40	26.0
22	22.00	6.00					5.70								7.90	7.50	27.0
23	7.00	6.00					3.73								7.90	7.30	26.0
24	14.00	7.00					3.74								7.90	7.30	26.0
25	25.00	5.00					3.83								7.90	7.40	27.0
26	26.00	2.00					4.68								7.90	7.40	26.0
27	9.00	3.00					4.63								7.80	7.20	26.0
28	20.00	6.00					4.76								7.80	7.20	26.0
29	66.00	5.00					4.89								7.40	7.30	27.0
30	60.00	6.00					4.75								7.80	6.80	
31	32.00	9.00					4.85								7.90	7.30	27.0

* Polyaluminium chloride

TABLE 2.1: PARTICULATE REMOVAL PROFILE (OCTOBER 1986)

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT *	COAG. AID	(1) PAC	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Treat
1	32.00	8.00					5.38								7.60	7.00	22.0
2	30.00	6.00					5.52								7.80	7.10	21.0
3	38.00	5.00					23.28								7.50	7.10	21.0
4	100.00	6.00					13.56								7.30	7.00	19.0
5	120.00	7.00					9.26								7.20	7.00	19.0
6	300.00	15.00					18.15								7.40	7.20	18.0
7	160.00	7.00					9.11								7.20	7.00	16.0
8	120.00	35.00					9.04								7.10	7.00	16.0
9	80.00	15.00					9.01								7.50	7.00	15.0
10	70.00	7.00					8.34								7.60	7.20	14.0
11	66.00	18.00					9.00								7.50	7.10	14.0
12	30.00	7.00					9.20								7.40	7.10	11.0
13																	
14	86.00	16.00					9.17								7.30	7.10	11.0
15	140.00	25.00					16.15								7.60	7.10	12.0
16	170.00	16.00					13.98								7.50	7.10	11.0
17	130.00	12.00					14.31								7.50	7.10	11.0
18																	
19	50.00	8.00					8.96								7.70	7.10	11.0
20	60.00	14.00					9.21								7.60	7.10	11.0
21	28.00	11.00					8.69								7.70	7.20	12.0
22	31.00	8.00					8.84								7.70	7.20	12.0
23	52.00	10.00					9.02								7.60	7.20	12.0
24	19.00	7.00					7.99								7.70	7.20	13.0
25	17.00	7.00					7.13								7.80	7.50	13.0
26	48.00	9.00					7.89								8.00	7.50	12.0
27	32.00	8.00					8.92								7.80	7.40	13.0
28	75.00	8.00					8.88								7.90	7.50	13.0
29	50.00	8.00					8.92								8.10	7.50	12.0
30	80.00	6.00					8.85								8.20	7.50	9.0
31	50.00	7.00					9.10								8.00	7.50	8.0

* Polyaluminium chloride

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JANUARY 1987)

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT *	COAG. AID	(1) PAC	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Treat
1	24.00						9.50								7.60	7.10	3.0
2																	
3	133.00						21.42								7.70	7.10	3.0
4	32.00						12.66								7.80	7.00	3.0
5																	
6	96.00						16.64								7.70	7.00	3.0
7	107.00						22.46								7.70	7.10	3.0
8																	
9	38.00						13.23								7.70	7.00	3.0
10	34.00						12.48								7.70	7.10	3.0
11																	
12	41.00						12.35								7.60	7.10	2.0
13	26.00						12.10								7.60	7.10	2.0
14																	
15	34.00						12.07								7.70	6.90	3.0
16	24.00						10.75								7.70	7.10	2.0
17																	
18	38.00						10.46								7.60	7.00	1.0
19	47.00						10.92								7.60	7.10	2.0
20																	
21	9.00						6.57								7.40	7.00	1.0
22	8.00						5.90								7.50	7.10	2.0
23																	
24	11.00						5.93								7.50	7.10	1.0
25	8.00						5.65								7.60	7.20	1.0
26																	
27	9.00						5.95								7.60	7.00	1.0
28	8.00						5.70								7.60	7.30	1.0
29																	
30	12.00						5.51								7.80	7.20	2.0
31	8.00						6.35								7.70	7.30	1.0

* Polyaluminium chloride

TABLE 2.1: PARTICULATE REMOVAL PROFILE (APRIL 1987)

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT *	COAG. AID	(1) PAC	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	38.00			0.50			33.90								7.60	7.20	5.0
2																	
3	60.00			0.76			38.00								7.80	7.50	5.0
4	75.00			0.62			19.00								7.60	7.30	4.0
5																	
6	43.00			0.37			31.00								8.00	7.20	5.0
7	48.00			0.08			101.00								7.60	7.10	5.0
8																	
9	40.00			0.08			31.00								7.80	7.10	7.0
10	47.00			0.07			30.00								7.50	7.20	8.0
11																	
12	58.50			0.13			31.00								7.90	7.10	10.0
13	55.00			0.16			30.00								7.60	7.20	9.0
14	23.00			0.42			23.60								7.40	7.00	8.0
15	8.80			0.13			23.60								7.70	7.00	10.0
16	8.00			0.11			22.80								7.50	7.00	9.0
17																	
18	9.90			0.01			21.60								6.70	6.70	15.0
19	21.00			0.04			21.40								7.40	6.90	11.0
20	9.00			0.03			21.70								7.60	7.20	14.0
21	35.00			0.05			25.80								7.80	7.10	11.0
22	26.00			0.03			25.10								7.50	6.90	13.0
23	29.00			0.06			24.30								7.70	7.10	14.0
24	28.00			0.11			25.80								7.90	7.00	12.0
25	17.00			0.06			25.10								7.50	7.00	12.0
26																	
27	36.00			0.15			22.00								6.60	6.60	13.0
28	90.00			0.17			22.00								8.40	7.90	13.0
29	26.00			0.10			28.40								7.00	6.70	13.0
30	60.00			0.09			28.20								8.10	7.60	12.0
31																	

* Polyaluminium chloride

WATER PLANT OPTIMIZATION STUDY
TILBURY WATER TREATMENT PLANT

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JULY 1987)

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT *	COAG. AID	(1) PAC	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	5.00			0.04			17.50								7.80	7.40	23.0
2	5.00			0.04			17.80								7.80	7.20	23.0
3	7.00			0.13			16.80								7.80	7.30	23.0
4	8.00			0.04			17.30								7.90	7.30	23.0
5	8.00			0.04			17.90								7.90	7.40	23.0
6	9.00			0.09			17.70								7.80	7.30	23.0
7	5.00			0.04			14.80								7.90	7.30	24.0
8	5.00			0.04			16.80								7.90	7.30	25.0
9	14.00			0.03			17.00								7.70	7.00	27.0
10	9.00			0.04			16.20								7.60	7.30	27.0
11	5.00			0.04			13.20								7.70	7.30	27.0
12	5.00			0.05			14.40								7.40	7.10	27.0
13	14.20			0.04			14.20								7.70	7.40	28.0
14	20.00			0.04			15.40								7.40	7.40	28.0
15	7.00			0.04			15.00								7.90	7.40	27.0
16	5.00			0.04			17.90								7.90	7.40	26.0
17	5.00			0.04			17.00								7.80	7.40	27.0
18	12.00			0.03			17.00								7.70	7.00	27.0
19	6.00			0.04			14.10								7.80	7.40	27.0
20	10.00			0.06			14.80								8.20	7.00	25.0
21	15.00			0.05			13.20								7.60	7.20	27.0
22	8.00			0.06			13.80								7.90	7.10	27.0
23	5.00			0.03			14.10								7.90	7.40	29.0
24	12.00			0.05			13.20								7.80	7.20	28.0
25	85.00			0.05			13.80								7.90	7.30	29.0
26	12.00			0.06			14.50								8.00	6.80	28.0
27	6.00			0.06			13.70								7.80	7.00	28.0
28	5.00			0.04			13.90								7.80	7.30	28.0
29	5.00			0.04			14.00								7.80	7.20	28.0
30	5.00			0.04			14.00								7.80	6.90	28.0
31	5.00			0.03			14.00								7.90	7.40	28.0

* Polyaluminium chloride

TABLE 2.1: PARTICULATE REMOVAL PROFILE (OCTOBER 1987)

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT *	COAG. AID	(1) PAC	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	112.00			0.12			18.60								7.50	7.30	19.0
2	92.50			0.07			20.20								7.40	7.50	19.0
3	130.00			0.05			18.10								7.50	7.10	18.0
4	50.00			0.05			16.40								8.00	7.10	15.0
5	60.00			0.06			18.10								7.00	7.50	14.0
6	50.00			0.10			16.90								7.10	7.60	14.0
7	112.00			0.04			17.40								7.70	7.20	14.0
8	90.00			0.07			17.80								7.80	7.20	14.0
9	30.00			0.10			22.00								7.80	7.00	11.0
10	60.00			0.06			18.90								7.80	7.20	13.0
11	100.00			0.06			16.70								7.80	7.40	13.0
12	20.00			0.06			13.80								7.70	7.00	13.0
13	18.00			0.06			14.00								7.60	7.10	12.0
14	20.00			0.04			11.80								7.70	7.20	12.0
15	20.00			0.05			11.80								7.80	7.00	13.0
16	20.00			0.04			11.70								7.60	7.10	13.0
17	18.00			0.02			11.70								7.80	7.20	13.0
18	20.00			0.06			13.00								7.70	7.10	13.0
19	14.00			0.03			13.70								7.60	7.10	13.0
20	17.00			0.04			11.80								7.70	7.20	13.0
21	35.00			0.06											7.50	7.10	13.0
22	23.00			0.05			11.80								7.60	7.20	11.0
23	24.00			0.06			11.70								7.70	7.20	11.0
24	53.00			0.10			18.90								7.50	7.20	11.0
25	31.00			0.08			16.60								7.50	7.20	10.0
26	20.00			0.06			13.30								7.50	7.30	11.0
27	30.00			0.08			12.70								7.50	7.20	11.0
28	39.00			0.09			14.30								7.70	7.20	10.0
29	25.00			0.06			12.40								7.70	7.20	10.0
30	29.00			0.07			12.40								7.70	7.20	10.0
31	22.00			0.04			12.90								7.60	7.20	11.0

* Polyaluminium chloride

TABLE 3.0: DISINFECTION SUMMARY

		1987						1986					
	CHEMICAL	PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JAN	Cl2 Demand												
	Cl2 Dosage	5.95	3.13	4.04	1.04	0.48	0.66	5.29	2.96	4.21	1.16	0.67	0.94
	Ammonia												
	SO2												
	Resid. Cl2 Free	0.75	0.22	0.47	1.1	0.5	0.74	1.05	0.45	0.77	1.4	0.7	1.11
	Resid. Cl2 Comb.												
	Resid. Cl2 Total												
	F-Dosage												
	F-Res.				1.12	0.9	1.01				1.1	0.8	1
FEB	Cl2 Demand												
	Cl2 Dosage	5.69	2.15	3.39	1.21	0.4	0.61	5.01	3.14	3.71	1.1	0.7	0.87
	Ammonia												
	SO2												
	Resid. Cl2 Free	0.8	0.2	0.51	1.4	0.42	0.72	1.3	0.75	1.06	1.47	0.95	1.19
	Resid. Cl2 Comb.												
	Resid. Cl2 Total												
	F-Dosage												
	F-Res.				1.4	0.09	0.92				1.42	0.87	1.08
MAR	Cl2 Demand												
	Cl2 Dosage	5.7	0.3	2.9	6.2	0.4	1.22	4.04	1.91	3.05	1.12	0.57	0.75
	Ammonia												
	SO2												
	Resid. Cl2 Free	0.9	0.1	0.47	1	0.4	0.69	1.4	0.9	1.13	1.5	1	1.23
	Resid. Cl2 Comb.												
	Resid. Cl2 Total												
	F-Dosage												
	F-Res.				2	0.08	1.1				1.1	0.75	1.01

Dosages and residuals in mg/L.

TABLE 3.0: DISINFECTION SUMMARY

	CHEMICAL	1987						1986					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
APR	Cl2 Demand												
	Cl2 Dosage	6.3	1.75	3.2	2	0.4	0.82	13.63	2.59	5.47	4.09	0.53	1.36
	Ammonia												
	SO2												
	Resid. Cl2 Free	0.82	0.02	0.46	1.2	0.5	0.75	1.5	0.14	0.73	1.5	0.9	1.15
	Resid. Cl2 Comb.												
	Resid. Cl2 Total												
	F-Dosage												
	F-Res.				1.5	0.7	0.97				1.12	0.75	1.02
MAY	Cl2 Demand												
	Cl2 Dosage	3.6	1.3	2.8	0.9	0.34	0.55	12.73	1.83	4.86	3.82	0.49	1.31
	Ammonia												
	SO2												
	Resid. Cl2 Free	1.2	0.16	0.46	0.85	0.4	0.65	1.25	0.15	0.85	1.35	0.7	1.08
	Resid. Cl2 Comb.												
	Resid. Cl2 Total												
	F-Dosage												
	F-Res.				3.5	0.7	1.2				1.17	0.95	1.03
JUN	Cl2 Demand												
	Cl2 Dosage	3.7	1.8	3.01	0.71	0.34	0.58	8.81	2.38	5.07	2.74	0.75	1.65
	Ammonia												
	SO2												
	Resid. Cl2 Free	0.99	0.26	0.6	0.97	0.32	0.66	1.4	0.6	1.01	1.3	0.37	0.89
	Resid. Cl2 Comb.												
	Resid. Cl2 Total												
	F-Dosage												
	F-Res.				1.2	0.3	0.56				1.45	0.42	0.98

Dosages and residuals in mg/L.

TABLE 3.0: DISINFECTION SUMMARY

	CHEMICAL	1987						1986					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JUL	Cl2 Demand												
	Cl2 Dosage	3.9	2.1	3.3	1.8	0.55	1.1	6.57	2.88	5.15	3.31	1.48	2.5
	Ammonia												
	SO2												
	Resid. Cl2 Free	1.8	0.18	0.55	1.6	0.48	0.87	1.5	0.7	1.12	1.3	0.2	0.84
	Resid. Cl2 Comb.												
	Resid. Cl2 Total												
	F-Dosage												
	F-Res.										1.12	0.75	0.95
AUG	Cl2 Demand												
	Cl2 Dosage	3.6	2.7	3.1	1.4	1.02	1.2	6.84	2.24	3.42	3.42	0.66	1.49
	Ammonia												
	SO2												
	Resid. Cl2 Free	1.2	0.64	0.93	1.7	0.8	1.4	1.5	0.7	1.31	1.4	0.55	1.1
	Resid. Cl2 Comb.												
	Resid. Cl2 Total												
	F-Dosage												
	F-Res.										1.12	0.6	0.93
SEP	Cl2 Demand												
	Cl2 Dosage	6.8	2.6	3.9	1.4	0.96	1.2	9.69	2.75	3.77	4.84	0.83	1.47
	Ammonia												
	SO2												
	Resid. Cl2 Free	1.9	0.16	0.9	1.7	0.54	1.3	3.2	0.25	1.02	4.38	0.1	0.91
	Resid. Cl2 Comb.												
	Resid. Cl2 Total												
	F-Dosage												
	F-Res.										1.1	0.65	0.93

Dosages and residuals in mg/L.

TABLE 3.0: DISINFECTION SUMMARY

	CHEMICAL	1987						1986					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
OCT	Cl2 Demand												
	Cl2 Dosage	5.9	3.3	4.29	0.98	0.54	0.73	10.34	3.09	5.34	4.87	0.87	2.05
	Ammonia												
	SO2												
	Resid. Cl2 Free	1.9	0.8	1.31	1.6	0.5	1.15	1.1	0.05	0.63	1.27	0.03	0.85
	Resid. Cl2 Comb.												
	Resid. Cl2 Total												
	F-Dosage												
	F-Res.										1.12	0.75	0.96
NOV	Cl2 Demand												
	Cl2 Dosage	5.2	2.9	3.42	1	0.62	0.7	5.23	2.72	3.74	1.6	0.58	0.89
	Ammonia												
	SO2												
	Resid. Cl2 Free	1.4	0.1	0.97	1.6	0.9	1.3	1.25	0.3	0.76	1.3	0.7	1.01
	Resid. Cl2 Comb.												
	Resid. Cl2 Total												
	F-Dosage												
	F-Res.										1.1	0.4	0.87
DEC	Cl2 Demand												
	Cl2 Dosage	5.4	1.1	3.77	1.67	0.67	1.1	7.94	3.33	4.64	1.43	0.61	0.87
	Ammonia												
	SO2												
	Resid. Cl2 Free	1	0.16	0.58	1.6	0.79	1.28	1.15	0.23	0.51	1.25	0.45	0.78
	Resid. Cl2 Comb.												
	Resid. Cl2 Total												
	F-Dosage												
	F-Res.										1.12	0.4	0.88

Dosages and residuals in mg/L.

WATER PLANT OPTIMIZATION STUDY
TILBURY WATER TREATMENT PLANT

TABLE 3.1: DISINFECTION PROFILE (JANUARY 1986)

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	C12		NH3	SO2	RESIDUAL C12			C12		NH3	SO2	RESIDUAL C12			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1																	1
2		4.04			0.85				1.01			0.70				1.05	2
3		4.79			0.97				0.96			1.40				1	3
4																	4
5		3.61			0.75				0.81			1.15				1	5
6		4.47			0.95				1.01			1.40				0.9	6
7																	7
8		2.96			0.70				0.67			1.10				0.85	8
9		5.17			0.70				1.16			1.15				1.05	9
10																	10
11		3.26			0.70				0.79			0.85				1	11
12		3.92			1.05				0.78			1.35				1	12
13																	13
14		3.43			0.70				0.79			1.05				1	14
15		4.09			0.55				0.82			1.15				0.8	15
16																	16
17		3.45			0.70				0.86			1.05				1.05	17
18		4.51			0.57				1.13			1.20				1.07	18
19																	19
20		3.62			0.70				0.90			1.00				1.05	20
21		5.12			0.45				1.14			0.85				0.95	21
22																	22
23		4.37			0.95				0.87			1.15				1	23
24		5.29			0.55				1.16			0.95				1	24
25																	25
26		4.89			0.75				0.98			1.05				1.05	26
27		5.16			0.80				1.03			1.15				1.1	27
28																	28
29		4.12			1.00				0.91			1.10				1	29
30		3.97			0.95				0.99			1.35				1.05	30
31																	31

Dosages and residuals in mg/L.

TABLE 3.1: DISINFECTION PROFILE (APRIL 1986)

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1																	1
2		2.65			1.05				0.53			1.20				1.1	2
3		2.61			1.20				0.68			1.35				1.07	3
4																	4
5		3.20			0.85				0.75			1.35				1.1	5
6					1.02							1.25				0.85	6
7		10.67			0.85				2.49			1.10				1.02	7
8		3.20			0.85				0.75			1.10				1.1	8
9		4.73			0.80				0.74			0.92				1.02	9
10		11.95			1.10				1.86			1.22				1.1	10
11		4.69			1.00				0.73			1.15				1.1	11
12		5.22			1.50				0.81			1.50				1	12
13																	13
14		3.93							0.64							1	14
15		3.28			1.25				0.76			1.50				0.75	15
16		5.79			0.87				1.62			1.25				1.02	16
17		2.59			0.95				0.60			1.10				1.1	17
18		4.37			0.32				1.18			0.90				1.05	18
19																	19
20		4.49			0.70				1.20			1.00				1	20
21		4.07			0.20				1.11			1.00				1.12	21
22		11.62			0.16				3.49			1.10				1.05	22
23		3.77			0.50				1.13			1.10				1	23
24		4.72			0.30				1.42			1.20				1.05	24
25		13.63			0.14				4.09			1.00				1	25
26		5.36			0.50				1.61			1.10				1	26
27		4.65			0.65				1.20			1.25				1.05	27
28		8.32			0.60				2.44			1.10				0.9	28
29		3.07			0.75				0.92			1.10				1.05	29
30		3.95			0.20				1.19			0.95				0.97	30
31																	31

Dosages and residuals in mg/L.

WATER PLANT OPTIMIZATION STUDY
TILBURY WATER TREATMENT PLANT

TABLE 3.1: DISINFECTION PROFILE (JULY 1986)

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	C12		NH3	SO2	RESIDUAL C12			C12		NH3	SO2	RESIDUAL C12			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1		5.94			1.10				2.37			1.00				1	1
2		5.55			1.35				2.22			1.00				0.95	2
3		5.32			1.15				2.36			1.00				1	3
4		5.66			1.20				2.77			1.10				1.05	4
5		5.91			1.32				2.89			0.75				1	5
6		6.48			1.05				3.17			0.50				0.9	6
7		5.11			1.15				2.50			0.80				0.9	7
8		5.81			1.30				2.84			1.30				0.87	8
9		6.11			1.10				2.99			1.10				1	9
10		6.57			1.00				3.21			0.85				1.05	10
11		6.36			1.15				3.11			0.85				0.97	11
12		5.68			0.75				3.18			0.47				0.9	12
13		5.79			0.95				3.31			0.72				0.92	13
14		4.63			0.85				2.47			0.75				0.9	14
15		5.34			0.70				2.73			0.20				1	15
16		5.57			0.85				3.06			0.57				1	16
17		5.23			1.00				[illegible]			0.30				1	17
18		4.73			0.90							0.65				0.9	18
19		5.78			0.80				[illegible]			0.80				0.95	19
20		5.68			1.20				2.70			0.70				0.85	20
21		4.60			1.30				2.30			0.92				0.75	21
22		4.80			1.30				2.40			0.97				1.12	22
23		3.86			1.50				1.99			1.12				1.1	23
24		3.65			1.35				1.88			1.00				1	24
25		2.88			1.35				1.48			1.10				0.9	25
26		5.11			1.40				2.59			1.02				0.92	26
27		4.84			1.35				2.18			1.02				1.05	27
28		4.37			1.20				1.97			1.05				1.02	28
29		3.66			0.85				1.72			0.60				0.85	29
30		3.86			1.00				1.89			1.02				0.75	30
31		4.87			1.15				2.38			0.87				1	31

Dosages and residuals in mg/L.

TABLE 3.1: DISINFECTION PROFILE (OCTOBER 1986)

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1		3.78			1.05				1.51			0.82				0.8	1
2		4.23			1.02				1.69			0.82				0.9	2
3		3.86			0.62				1.62			0.52				0.8	3
4		6.26			0.10				3.03			0.03				0.95	4
5		8.77			0.70				4.87			0.50				0.95	5
6		5.21			0.52				2.95			0.37				1	6
7		5.36			0.05				2.50			0.04				1	7
8		4.28			0.60				2.12			0.80				1	8
9		4.27			0.95				2.45			0.60				1	9
10		4.52			0.45				2.60			1.20				1	10
11		7.18			0.65				3.59			0.75				1	11
12		6.54			0.55				2.90			1.20				1	12
13																	13
14		3.26			0.50				1.45			0.70				1	14
15		3.95			0.40				1.34			1.27				1	15
16		5.05			0.62				1.72			1.17				0.97	16
17		6.52			0.55				2.22			1.15				0.9	17
18					1.10												18
19		3.75			1.07				1.26			1.17				0.75	19
20		3.09			0.50				0.87			0.77				1.1	20
21		3.90			0.30				1.13			0.80				1.12	21
22		9.42			0.65				2.72			0.80				0.9	22
23		3.20			0.85				0.93			0.95				0.9	23
24		3.69			0.57				1.07			0.82				0.8	24
25		10.13			0.70				2.93			0.92				0.9	25
26		4.40			0.60				1.27			1.00				1.1	26
27		3.54			0.65				1.02			1.10				1	27
28		7.97			0.75				2.30			1.12				1.02	28
29		4.47			0.55				1.29			1.05				1.05	29
30		4.08			0.70				1.18			1.05				1.05	30
31		10.34							2.99			1.15				0.9	31

Dosages and residuals in mg/L.

TABLE 3.1: DISINFECTION PROFILE (JANUARY 1987)

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1		5.95			0.25				1.04			0.65				1.1	1
2																	2
3		4.46			0.22				0.80			0.62				1	3
4		5.60			0.22				1.01			0.70				0.9	4
5																	5
6		3.84			0.35				0.69			0.72				1.1	6
7		4.50			0.75				0.72			1.10				1	7
8																	8
9		3.71			0.75				0.58			0.95				0.92	9
10		4.20			0.60				0.74			0.70				1	10
11																	11
12		3.28			0.50				0.49			0.82				1.12	12
13		3.72			0.60				0.56			0.80				1.05	13
14																	14
15		3.55			0.30				0.55			0.50				1.05	15
16					0.65							0.90				0.9	16
17																	17
18		4.60			0.42				0.82			0.70				0.9	18
19		5.12			0.32				0.91			0.60				1	19
20																	20
21		3.23			0.55				0.48			0.80				1.05	21
22		3.76			0.60				0.56			0.80				0.97	22
23																	23
24		3.54			0.42				0.49			0.65				1.05	24
25		4.38			0.50				0.61			0.75				1	25
26																	26
27		3.22			0.50				0.48			0.72				I	27
28		3.74			0.65				0.56			0.85				1	28
29																	29
30		3.13			0.38				0.49			0.52				1.12	30
31		3.21			0.30				0.51			0.60				1	31

Dosages and residuals in mg/L.

TABLE 3.1: DISINFECTION PROFILE (APRIL 1987)

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	C12		NH3	SO2	RESIDUAL C12			C12		NH3	SO2	RESIDUAL C12			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1		3.70			0.30				0.80			0.70				0.9	1
2																	2
3		3.50			0.17				0.84			0.62				1.4	3
4		3.40			0.60				0.79			0.80				1	4
5																	5
6		3.40			0.44				0.75			0.77				0.9	6
7		3.50			0.50				0.75			0.78				1	7
8																	8
9		3.40			0.42				0.82			0.74				1.05	9
10		4.00			0.25				1.80			0.64				1	10
11																	11
12		3.30			0.22				0.83			0.67				0.85	12
13		6.30			0.34				1.70			0.69				1	13
14		3.33			0.65				0.75			1.00				1	14
15		2.80			0.69				0.58			0.87				0.95	15
16		2.20			0.50				2.00			0.84				1	16
17																	17
18		1.75			0.44				0.74			0.86				0.9	18
19		5.70			0.02				1.40			0.62				1	19
20		2.00			0.75				0.58			1.20				0.7	20
21		2.20			0.60				0.80			0.70				0.9	21
22		2.50			0.60				0.40			0.80				0.9	22
23		2.30			0.39				0.41			0.57				0.72	23
24		2.20			0.35				0.51			0.50				0.7	24
25		2.50			0.41				0.60			0.70				0.9	25
26																	26
27		2.10			0.50				0.44			0.65				1.5	27
28		3.10			0.50				0.44			0.70				1	28
29		2.90			0.82				0.43			0.84				0.9	29
30		2.90			0.50				0.60			0.70				1	30
31																	31

Dosages and residuals in mg/L.

TABLE 3.1: DISINFECTION PROFILE (JULY 1987)

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1		2.90			0.59				0.55			0.73				*	1
2		3.30			0.20				0.66			0.50				*	2
3		3.20			0.51				0.63			0.61				*	3
4		3.50			0.33				0.64			0.50				*	4
5		3.40			0.43				0.62			0.57				*	5
6		3.50			0.66				0.64			0.77				*	6
7		3.60			0.68				0.65			0.77				*	7
8		3.10			0.80				0.56			1.30				*	8
9		3.00			0.60				0.90			0.56				*	9
10		3.10			0.40				0.57			0.62				*	10
11		2.10			0.54				1.40			0.70				*	11
12		3.20			0.63				0.71			0.53				*	12
13		2.50			0.28				0.70			0.52				*	13
14		3.40			0.45				0.91			0.48				*	14
15		3.50			0.18				1.60			0.64				*	15
16		3.50			0.37				1.40			1.10				*	16
17		3.90			0.55				1.30			1.10				*	17
18		3.30			0.55				0.99			0.84				*	18
19		3.50			0.38				1.40			0.88				*	19
20		3.70			0.67				1.10			0.88				*	20
21		3.20			0.27				0.86			0.58				*	21
22		3.40			0.20				1.80			0.64				*	22
23		3.50			0.38				1.10			0.69				*	23
24		3.30			0.54				1.40			1.10				*	24
25		3.40			0.36				1.70			1.40				*	25
26		3.50			0.18				1.80			1.08				*	26
27		3.70			1.80				1.50			1.40				*	27
28		2.70			0.71				1.40			1.30				*	28
29		3.00			0.65				1.40			1.40				*	29
30		3.40			1.00				1.60			1.20				*	30
31		3.50			1.30				1.40			1.60				*	31

Dosages and residuals in mg/L
* Data not available

TABLE 3.1: DISINFECTION PROFILE (OCTOBER 1987)

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	C12		NH3	SO2	RESIDUAL C12			C12		NH3	SO2	RESIDUAL C12			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1		5.90			1.40				*			0.90				*	1
2		5.50			1.90				*			1.60				*	2
3		5.30			1.20				*			1.00				*	3
4		5.30			1.20				*			1.10				*	4
5		5.70			1.80				*			1.20				*	5
6		3.30			1.60				*			1.30				*	6
7		5.00			1.50				*			1.20				*	7
8		3.30			1.40				*			1.20				*	8
9		5.60			1.40				*			1.00				*	9
10		3.80			1.60				*			1.10				*	10
11		4.50			1.30				*			1.10				*	11
12		3.90			1.40				*			1.10				*	12
13		3.90			1.50				*			1.40				*	13
14		4.00			1.60				*			1.60				*	14
15		3.70			1.40				*			1.40				*	15
16		3.70			1.30				*			1.20				*	16
17		4.00			1.90				*			1.30				*	17
18		3.40			0.90				*			0.90				*	18
19		3.80			1.50				*			1.30				*	19
20		4.00			1.40				*			1.40				*	20
21		3.90			1.00				*			0.80				*	21
22		4.50			0.90				*			0.90				*	22
23		3.60			0.90				*			1.30				*	23
24		3.70			1.10				*			0.70				*	24
25		5.00			1.10				*			1.20				*	25
26		3.90			1.50				*			1.50				*	26
27		3.70			1.20				*			0.90				*	27
28		5.50			0.80				*			0.50				*	28
29		3.60			0.88				0.98			1.30				*	29
30		3.70			0.86				0.54			0.91				*	30
31		4.40			1.20				0.67			1.30				*	31

Dosages and residuals in mg/L
* Data not available

APPENDIX D

Terms of Reference

WATER PLANT OPTIMIZATION STUDY
INTRODUCTION

Introduction

The information contained herein consists of a preamble and general terms of reference for the "Plant Consultant".

Basic Premise of the Water Plant Optimization Study

The majority of drinking water supply facilities in Ontario have treatment directed at microbiological disinfection and/or removal of suspended material.

The purpose of the Water Plant Optimization Study (WPOS) is to document and review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on the removal of particulate materials and disinfection processes.

The following items relate to the emphasis on particulate removal in a plant evaluation:

- Organic contaminants (dioxins, PAHs) are associated, at least in part, with particulates.
- Particulates themselves have health-related limits (turbidity/bacteria).
- In striving for excellence in water treatment, it is important to examine all possible approaches, but first optimum use should be made of the processes already in place.

The Drinking Water Surveillance Program (DWSP) is a continuously updated base of information on Ontario water plants and water quality. Appended herewith is a detailed description of the DWSP and the DWSP Questionnaire (Appendix A). In connection with the DWSP, a plant investigation and process evaluation study is required for each plant entering the program.

The Drinking Water Surveillance Program and the Water Plant Optimization Study are being co-ordinated for the following reasons:

- Some of the components of interest are the same, and cost savings can be realized.
- The DWSP should focus on plants which have been optimized and are producing the best possible water; documentation of plants which are known to be inefficient is non-productive.

General Information

1. Operator training and certification is an important component of plant optimization. Plans are already underway with the MOE/Municipal Engineers Association (MEA) to implement such a program.

2. The mechamism for ensuring ongoing optimization will be through an annual inspection by MOE staff or consultants, or a combination of the two.

3. The study has been organized with a team approach in mind; thus, progress reports and a meeting with the Project Committee are required as the work progresses.

4. It is not the intent of this study to provide a detailed implementation scheme for plant rehabilitation; however, it is necessary to scope the feasible short and long-term process modification, if required, to achieve optimum disinfection and contaminant removal.

5. All information provided in the study must conform to the Ministry's "Metrication Guidelines for Consulting Engineers", and existing information used for all designs, drawings, specifications, etc., for this project must also be converted into metric (SI) units.

Organization

On the following page is an organization chart which describes the various groups involved in each plant study.

Project Committee

A "Project Committee" will be struck for each water plant. The "Project Committee" will consists of Municipal and MOE representatives and a "Prime Consultant". The "Project Committee" will formulate a set of specific terms of reference for the "Plant Consultant", using the "General Terms of Reference" contained herein as the basis. It is important that the same general approach be utilized for all plants; therefore, only some specific inclusions should be allowed in the plant specific terms of reference.

The "Project Committee" will direct the "Plant Consultant" in carrying out work described in the plant specific terms of reference. The "Project Committee" will also review the progress of the work and evaluate the final report.

WATER PLANT OPTIMIZATION STUDY

Reporting & Co-ordination

MOE UPPER MANAGEMENT

C.E. McIntyre & J.N. Bishop

CO-ORDINATION GROUP

K. Roberts
G. Martin
R. Hunsinger
W. Gregson
J. Budziakowski

41 PROJECT COMMITTEES

1. Prime Consultant
2. Municipal Management
3. Municipal Operation
4. MOE Regional Representative
5. MOE Water Resources Branch
6. MOE Project Engineering Branch
7. MOE Environmental Approvals Branch

41 PLANT CONSULTANTS

Prime Consultant

The "Prime Consultant" for the study will co-ordinate all of the water plant optimization studies by carrying out such tasks as:

- Setting up project committees
- Participate in development of the specific terms of reference for each plant
- Liaison with "Plant Consultants" regarding progress reports, meetings, and final reports.
- Preparation of a report summarizing the results of the 41 plant studies.

Plant Consultant

The "Plant Consultant" will carry out the data gathering, interpretating and recommendation steps outlined in Tasks 1 through 8.

The "Plant Consultant" must provide staff with extensive experience in evaluation of existing water treatment facilities who will maintain direct involvement in all phases of the project.

Purpose

To review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on particulate materials and disinfection processes.

Work Tasks

1. Receive an information package from the MOE. Review the information provided and meet with the MOE staff, if required, to discuss the project.

2. Document the quality and quantity of raw and treated waters.

3. Define the present treatment processes and operating procedures. Prepare a progress report on Works Tasks 1-3 for the Project Committee.

4. Assess the methods of efficient particulate removal which would utilize the present major capital works of the plant. Evaluate the particulate removal efficiency and sensitivity of operation, assuming optimum performance of the plant.

5. Assess current disinfection practices and possible improvement methods.

6. Describe possible short and long-term process modifications to obtain optimum disinfection and contaminant removal.

7. Prepare a draft report for the project committee's review.

8. Prepare the final report.

1. RECEIVE AN INFORMATION PACKAGE FROM THE MOE. REVIEW THE INFORMATION PROVIDED AND MEET WITH THE MOE STAFF, IF REQUIRED, TO DISCUSS THE PROJECT.

Elements of Work

(a) Receive an information package from the MOE concerning the plant and the study. This package includes a general terms of reference, a general table of contents for organizing the study in a manner consistent with other plant reports, the WPOS reporting tables and a copy of Ontario Drinking Water Objectives.

(b) Review the information and prepare for a meeting to initiate the work on the project, including preparation of a schedule of manpower and staff committments.

(c) Meet with the MOE to discuss the available data, the terms of reference, and the project staff and work schedule. If a consultant is carrying out more that one study it may not be necessary to meet with the MOE at the start of each study.

2. DOCUMENT THE QUALITY AND QUANTITY OF RAW AND TREATED WATERS.

Elements of Work

(a) Prepare a monthly summary of maximum, minimum, and average flows for the last three consecutive years (Table 1.0). Address any discrepancies which exist between raw and treated flow rates.

(b) Based on the above, briefly review and tabulate for the last three years, the monthly maximum, minimum, and average per capita flow for the total population served by the plant (Table 1.1). Compare the plant data with typical per capita flows for the local region. Indicate major consumers who may influence the figures.

(c) Document the methods of measuring the raw and treated water flow rates.

(d) Summarize, for the last three consecutive years, where available, the raw and treated water; turbidity, colour, residual aluminum/iron, pH, temperature and treatment chemical dosages (other than disinfection and fluoridation). The summary should indicate the monthly daily average and maximum and minimum day (Table 2.0).

For the same three year period, tabulate also the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with particulate removal occurred (Tables 2). Document enough data to define and evaluate those problems.

Record other data, such as particulate counting, suspended solids, and algae counting (Table 5.0) which could reflect on particulate removal efficiency.

Document the source and methods used in determining all information.

A comparison should be made between the plant and outside laboratory information to ascertain the relative validity of the data. For plant data, emphasis should be given to plant laboratory tests rather than continuous process control instruments.

(e) Summarize for the last three consecutive years, where available, the disinfectant demand, dosages (including all disinfection related chemicals and residuals) for all application points as well as fluoridation dosage and residual. The summary should indicate the monthly daily average and maximum and minimum day (Table 3.0).

For the same three year period, tabulate (Tables 3) the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with chlorine residuals and/or positive bacterial tests identified in Table 6. Document enough data to define and evaluate those problems.

Document the methods of dosage evaluation and residual measurements, and establish the validity of the data provided.

(f) Prepare a summary, based on at least three years of data, of the raw and treated water quality testing data for physical, microbiological, radiological, and chemical water quality information (Table 4). Document as much data as is needed to show possible seasonal trends in water quality. Where possible, show corresponding sets of raw and treated water quality information.

Document the source and methods used in determining all water quality information and establish the validity of the data, comparing plant and outside laboratory data.

(g) Tabulate, for the last three consecutive years, the raw and treated water bacterial test information at the plant (Table 6).

Document the source and methods used for all data provided.

(h) Document the water sampling systems (source, pump, line-material and size, vertical rise velocity sampling location) used in the plant (similar to DWSP Questionnaire in Appendix A).

(i) Prepare a summary of inplant testing including Test, Sampling Point, Testing Frequency, Reporting Frequency, Testing Instrumentation including calibration.

(j) Identify other water quality concerns, not related to particulate removal or disinfection, which should be considered as part of the assessment phase of this evaluation program.

3. DEFINE THE PRESENT TREATMENT PROCESSES AND OPERATING PROCEDURES. PREPARE A PROGRESS REPORT ON WORK TASKS 1-3 (8 COPIES), FOR THE PROJECT COMMITTEE.

Elements of Work

(a) Where drawings are available, assemble sufficient record drawings of a reduced size, to document the general site layout and the interrelationship of major plant components. If available, include a process and piping diagram (PAPD) of the plant operations.

(b) Prepare a simplified block schematic of all major plant components including chemical systems and indicating design parameters. Appendix B is an example of the required standard schematic.

(c) Prepare a photographic record of the plant facilities, illustrating all of the major plant components and chemical feed systems. The record should include approximately 30-40 coloured (9 cm x 12 cm) (or 10 cm x 15 cm) prints, suitably labelled. The progress and draft reports may include photocopies in lieu of the prints.

(d) Tabulate the design parameters for all the major plant components, with emphasis on the process operations, including chemical feeds. This information, as a minimum, must be consistent with the DWSP Questionnaire (Appendix A) and must be confirmed and verified by field observations. The design parameters should be evaluated at design, rated and actual operational flows.

(e) Prepare a summary of how the plant is operated, including chemical dosage control, such as jar testing information, filter backwashing procedures and initiation, and pumping and flow control.

(f) Document all reported and other apparent problems in plant operations and/or in the distribution system related to water quality. In addition list the health related parameters which exceed the Ontario Drinking Water Objectives (Table 7).

(g) Submit 8 copies of the progress report to the Prime Consultant for distribution to the Project Committee.

4. ASSESS THE METHODS OF EFFICIENT PARTICULATE REMOVAL WHICH WOULD UTILIZE THE PRESENT MAJOR CAPITAL WORKS OF THE PLANT. EVALUATE THE PARTICULATE REMOVAL EFFICIENCY AND SENSITIVITY OF OPERATION, ASSUMING OPTIMUM PERFORMANCE OF THE PLANT.

Elements of Work

(a) Assess the validity and implication of all information relating to particulate removal provided in Work Tasks 1 and 2 with emphasis on method, metering and sampling, etc.

(b) Using information provided in Work Tasks 1, 2 and 3 evaluate the plant's particulate removal efficiency. The basis of minimum particulate removal should be 1.0 F.t.u. It should, however, be recognized that it is desirable to strive for an operational level which is as low as is achievable.

(c) Conduct an evaluation of possible optimum performance alternatives. Include jar testing using established industry practice.

(d) Evaluate the feasibility of optimum removal using the existing plant capital works. This evaluation should consider the worst case water quality conditions, even though field testing data may not be available during the initial phase of the study (see Work Task 7).

(e) Describe the operational procedures, management strategies, and equipment required for various feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation of the alternatives.

5. ASSESS CURRENT DISINFECTION PRACTICES AND POSSIBLE IMPROVEMENT METHODS.

Elements of Work

(a) Assess the validity and implication of all information relating to disinfection provided in Work Tasks 1, 2 and 3 with emphasis on method, metering and sampling etc.

(b) Using the information provided in Work Tasks 1, 2 and 3 evaluate the plant's ability to disinfect the water. The basis of minimum disinfection should be to ensure a water quality as described in the Ontario Drinking Water Objectives.

(c) Conduct an evaluation of possible optimum disinfection procedures for the plant, with consideration also given to the reduction of chlorinated by-products in the treated water.

(d) Evaluate the feasibility of the various alternatives using the existing plant capital works.

(e) Assess the relative merits of the alternatives. Describe the operational procedures, management strategies, and equipment required for the feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation for the alternatives.

6. DESCRIBE POSSIBLE SHORT AND LONG-TERM PROCESS MODIFICATIONS TO OBTAIN OPTIMUM DISINFECTION AND CONTAMINANT REMOVAL.

Elements of Work

(a) Prepare a list of modifications which should be considered for detailed implementation evaluation. Provide an estimated cost and possible schedule for implementation for each of the proposed modifications.

It is not the purpose of this study to provide a detailed implementation scheme for plant rehabilitation. It is, however, necessary to scope the feasible short and long-term process modifications required to achieve optimum disinfection and contaminant removals.

(b) Incorporate (a) above in the draft report.

7. PREPARE A DRAFT REPORT FOR THE PROJECT COMMITTEE'S REVIEW. (8 COPIES).

Elements of Work

(a) The report must include all information for Work Tasks 1-6.

The information must be organized and presented in a logical and co-ordinated fashion. A general table of contents (Appendix C) is provided for organizing the material in a manner consistent with other plant reports.

Submit the draft report for review by the Project Committee.

(b) Meet with the Project Committee on site at least one week after submission of the report.

(c) Prepare a separate letter report containing recommendation(s) concerning the need for additional field testing to cover quality conditions not available during the period of this study. The Project Committee may decide to delay completion of the final report until field data can be obtained to confirm the predictions of performance for the worst case water conditions.

8. PREPARE THE FINAL REPORT.

Elements of Work

(a) Conduct additional field testing if required. Discuss the implementations of the results with the Project Committee if the results differ from the predicted performance.

(b) Amend the report as per review comments, incorporating additional field data if required.

(c) Submit 25 copies of the final reports (including the colour photographs) to the MOE for distribution.